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MATERIALS

Synthesis of New Explosives and Binders within the New U.K.	
Defence Research Agency	R.W. Armstrong 21

This article presents a summary of a meeting where participants discussed topics related to chemical synthesis of binder systems. The discussions also covered some consideration of explosives and propellant composite properties.

Developments in the Science and Technology of Composite	
Materials - Fourth European Conference on Composite Materials	Michael J. Koczak 23

This conference addressed the following topics: fabrication, fatigue, constituents, impact and energy absorption, nondestructive evaluation, interfaces, metal matrix composites, analysis methods, applications, ceramic matrix composites, carbon carbon composites, properties, delamination, and thermoplastics. Dr. Koczak highlights and summarizes selected presentations.

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AEROSPACE

European Space Developments and Programs at the 29th Farnborough International Aerospace Exhibition

by CDR Robert C. Treviño, Office of Naval Research/Naval Research Laboratory Technology 410 Reserve Unit. CDR Treviño performed active duty for training in the Aerospace Systems Technology Division of the Office of Naval Research European Office.

Introduction

The 29th Farnborough International Aerospace Exhibition, the largest aerospace event of 1990, was held September 2-9. The Society of British Aerospace Companies organizes this major biennial aerospace event. Farnborough had the expected high attendance, but few new European space programs or initiatives were presented or announced. The European community appears to be maturing its spacecraft technology, especially in the area of launch vehicles, spacecraft design, and satellite communications.

All the major European countries involved in space activities were represented at Farnborough--the U.K., France, Federal Republic of Germany (FRG), Italy, Spain, and the Netherlands. The Soviet Union did not have a space exhibit, but was very active in the aircraft portion of this event. The FRG had the largest and most active exhibit of space programs, components, systems, and research. The British National Space Center (BNSC) was the only government space agency represented.

Because of the wide variety of space topics covered at Farnborough, I present this report by country instead of by programs or specialty. Most space programs in Europe are multinational, either funded proportionally by the European Space Agency (ESA) nor joint commercial ventures where the technology mix is appropriate. The major European countries are also pursuing their own space research and development programs to enhance their technology base for commercial and scientific purposes. European autonomy is the goal of all these efforts in both manned and unmanned space programs. Particular attention was given to new technology demonstrating programs and items of interest to the U.S. Navy.

United Kingdom

British Aerospace (BAe) and Marconi Space Systems were the main British aerospace companies represented. Two government agencies, British National Space Center (BNSC) and the British Remote Sensing Center (BRSC), also participated.

The following is a summary of some of BNSC's technology development programs:

- **Gallium Arsenide (GaAs) Solar Cells.** The BNSC has an active program to improve the performance of GaAs solar cells. Currently, GaAs solar cells with a beginning of life efficiency of 18 percent are commercially available. The GaAs solar cells are very thin and therefore offer the possibility of very light solar cells for a weight-saving on future spacecraft. Since GaAs solar cells have improved performance at high temperatures, BNSC is studying their use in novel solar array designs that use optical concentrators. In this method, solar energy is concentrated using either mirrors or lenses and leads to a much smaller area of solar cells. This research could lead to lighter solar arrays.
- **Closed-Cycle Coolers for Long-Life Space Applications.** Remote sensing instruments that operate in the infrared region require cooling. The BNSC is managing research into improving the sensitivity and signal-to-noise ratio by cooling the infrared detectors to very low temperatures. The Rutherford Appleton Laboratory is performing the actual research. A cooler having 875 MW of cooling power at 80k for 30 watts electrical input power has already been developed and qualified for space applications. This cooler is now commercially available and will be used on the ERS Along Track Scanning Radiometer. A larger multi-state cooler is currently being built as part of a future program concerned with the development for ESA of a long-life 4-K cooler.

- **Along Track Scanning Radiometer (ATSR).** Managed by BNSC and built by the Rutherford Appleton Laboratory, this instrument is designed to measure sea surface temperatures from space to the accuracy of a few tenths of a degree centigrade. The ATSR is part of ERS-1 scheduled to be launched during 1991. Sea surface temperature measurements from the ATSR, together with data from the other ERS-1 sensors (SAR, scatterometer, and altimeter) will enable a better understanding of the complex interactions between the ocean and the atmosphere. High sensitivity on ATSR is achieved by cooling its infrared detectors to liquid nitrogen temperatures using the closed-cycle, sterling cooler discussed earlier. The instrument's accuracy is maintained by an internal calibration facility.

The following is a summary of BAe's only new development:

- **Horizontal Takeoff and Landing (HOTOL).** As background, HOTOL is the BAe and Rolls-Royce proposed unmanned, reusable, single-stage to orbit aerospace plane that would operate from conventional runways. The propulsion system is based on a concept of an integrated dual-role powerplant enabling air-breathing propulsion through the atmosphere when HOTOL's engines would burn liquid hydrogen and atmospheric air and then switch to a space mode using liquid hydrogen and liquid oxygen. On re-entry to the atmosphere, the engines return to an air-breathing mode. Details of the HOTOL RB.545 engines remain classified secret by the Ministry of Defence. The only new development in the HOTOL program was an announcement by BAe and the Soviet Ministry of Aviation of a 6-month study that would use the giant Soviet An-225 Mriya (Dream) cargo aircraft as a launch platform for a modified version of the HOTOL. This concept, called the Interim HOTOL, would not use the classified RB.545 engines. The Interim HOTOL concept would replace these engines with Soviet-designed rocket engines. The An-225 would carry HOTOL up to 9 km (30,000 ft) and 400 mph. The HOTOL would then be released and use its Soviet rocket engines to reach orbit. The Soviet studies are going to concentrate on the compatibility of the HOTOL and the An-225 to confirm that inflight separation is possible. This study appears to be more an exercise in British-Soviet cooperation than an actual program.

Federal Republic of Germany

In 1990, a major event in the FRG was the merger of the four leading aerospace corporations into one space conglomerate, Deutsche Aerospace (DASA). The DASA was formed to remain competitive in major international projects. The four subsidiaries are Dornier GmbH, MBB, MTN Group, and Telefunken Systemtechnik GmbH. Dornier and MBB are responsible for space systems development. The DASA now has an extremely large technological potential that enables it to undertake any large major international space program.

The following is a summary and status of the new major DASA programs:

- **European Remote Sensing Satellite (ERS).** As background, the French originally proposed SPOT as an ESA program, but were refused. Thus, SPOT is a major commercial French program with minority Swedish and Belgian participation. The ESA decided to create the ERS program to provide images of the Earth in the microwave spectrum. Primary objectives of the multi-mission payload are in oceanographic science; e.g., ocean current patterns, wind velocity, ice coverage. The ESA's radar allows for observations through clouds and darkness. The main payload is the active microwave instrumentation, which consists of a C-band synthetic aperture radar (SAR) with 30-m resolution and a swath width of 99 km. The other payloads are a scatterometer, radar altimeter, along track scanning radiometer, and a microwave sounder. The ESA has approved the funds for two ERS spacecraft. The ERS-1 will be launched on April 1, 1991, on an Ariane V44 launch vehicle; the ERS-2 will be launched in 1994.
- **Modular Opto-electronic Multispectral/Stereo Scanner (MOMS).** An earlier version of this instrument was flown on the space shuttle in 1983 and 1984 when it was mounted on the retrievable Shuttle Pallet Satellite (SPAS). The DASA is currently developing MOMS-02 for cartography and thematic mapping for the Spacelab D2 mission on behalf of the Federal Ministry of Research and Technology (BMFT) and the FRG Aerospace Research Establishment (DLR).

- **CLUSTER.** The ESA has just recently awarded the contract to DASA/Dornier to develop CLUSTER, a series of four satellites that will study the magnetosphere. CLUSTER is part of the ESA Solar-Terrestrial Science Program (STSP), which is one of four major missions known as the ESA Horizon 2000 Program. The four CLUSTER spacecraft will investigate the sun and the processes in the Sun-Earth environment.
- **SÄNGER.** This MBB program has been present for several years, but there have been some new developments. As background, SÄNGER is a concept for a future European reusable two-stage, low-cost space transportation system for crew and cargo. The first stage will be on air-breathing, turbo-ramjet hypersonic aircraft with cruise capability. The second stage will be a reusable, rocket-propelled winged vehicle called the Hypersonic Orbital Upper State (HORUS) for manned missions or an expendable rocket stage for cargo transport called the Cargo Upper Stage (CARGUS). To demonstrate the technical feasibility, DASA proposes a hypersonic technology experimental aircraft (HYTEX) be built. This will allow testing of key technologies under flight conditions previously not attainable with conventional air-breathing systems. Recently, DASA began testing a gaseous hydrogen-fueled ramjet engine designed to operate at up to Mach 4. This work is leading to an air-breathing propulsion system for the first stage of the proposed SÄNGER.

France

The main French aerospace companies represented were Arianespace, Aerospatiale, Matra, and Alcatel Espace. Matra and the Marconi Space Systems (British) recently formed Matra Marconi Space as a joint venture. The following is a summary and status of some new Arianespace programs:

- **Light Satellite (Lightsat) Launch Services.**

Arianespace is the first major commercial launch vehicle company to offer launch services for small satellites. This launch service is for three categories of lightsats: spacecraft weighing up to 800 kgs, up to 1,100 kgs, and less than 50 kgs (microsats). All of these lightsat categories have obvious volume restrictions also. These spacecraft are considered secondary payloads and must be compatible with the primary payload's requirement. For the heavier spacecraft up to 1,100 kgs, Arianespace has two systems for supporting them. The Spelda Dedicated Satellite (SDS) is used when the launch vehicle is launching two or more satellites simultaneously. The primary payload is carried on top of the SDS. The High Density Satellite (HDS) is used for

spacecraft up to 1,100 kg. Also, the HDS is mounted below a primary payload. Microsats are carried aboard a system called the Ariane Structure for Auxiliary Payloads (ASAP). The ASAP can carry up to six spacecraft on a structural ring mounted between the main payload and launch vehicle equipment bay. After the main payloads are deployed, the lightsats or microsats are separated by spring-loaded pyrotechnic devices. Table 1 refers to these lightsat systems and compares them to a main payload. The obvious problem that lightsats have when flying on Arianespace is that they are completely dependent on the main payload for schedule, altitude, and inclinations. The number of microsats is also dependent on the performance margin that remains on the launch vehicle.

Table 1. Comparison of Lightsat Systems to Main Payload

Ariane Systems	Lightsat Constraints	
	Weight (Kgs)	Volume
SDS	800 Max	10 cm Max
HDS	1,100 Max	10 cm Max
ASAP	50 Max	35x35x60 cm
Primary payload	1,900-4,200	4m DIAx 1m HT

The main program and a new one by Aerospatiale are:

- **HERMES.** The ESA-sponsored reusable spaceplane has been changed drastically since 1989 to reduce its weight. These changes are limiting its operational usefulness and flexibility. The HERMES has no open payload bay. Therefore, it has no capability to carry and deploy spacecraft. The crew has been reduced from six to three. Also, ejection seats have been baselined for HERMES. To reduce the landing weight of the HERMES, many systems that were originally in the vehicle have been moved into a resource module which is completely expendable and are jettisoned at the end of a mission. This module is called the HERMES Resource Module (HRM). The HRM includes an airlock, a docking module that is to be compatible with the International Space Station Freedom, the Soviet Space Station MIR, and the ESA Columbus Free-Flying Laboratory (CFFL). Also, the HRM will have a remotely operated manipulator arm. Apparently, this arm is also expendable at the end of the mission. The HERMES' primary mission will be to service various ESA free-flying platforms in LEO, such as the CFFL. The HERMES program should receive a final go-ahead to start building the spaceplane during a June 1991 meeting of the technical ministers of ESA member states. The

HERMES program is a key part of Europe's goal of space autonomy.

- **Study Towards European Autonomous Manned Spaceflight (STEAMS).** This is a new ESA-sponsored study of concepts of autonomous European Space Station (ESS). The STEAMS is mainly developing scenarios for an evolving modular architecture using a combination of elements already planned for use by the Columbus program. An initial ESS would be composed of the CFFL, another pressurized module serving as a habitat and laboratory, and an escape vehicle for emergency crew safety and return. Both unmanned Ariane 5 and HERMES flights would be needed to assemble the ESS. This study emphasizes again the European goal of space autonomy.

Italy

The two major Italian aerospace companies represented were Aeritalia Space Systems Group and Selenia Spazio. Aeritalia Space Systems Group, is the principal national company responsible for Italian Space Agency (ASI), ESA, and commercial programs. The following is a summary and status of the major Aeritalia programs:

- **The ESA Columbus Program.** This program consists of three key elements:
 1. **Columbus Attached Pressurized Module (APM)** - a permanent part of the international space station Freedom used for microgravity research
 2. **Columbus Free Flying Laboratory (FFL)** - an autonomous laboratory co-orbiting with the space station
 3. **Columbus Polar Platform** - an autonomous platform for carrying payloads for earth observations and scientific experiments.

Aeritalia is prime contractor for the APM and the FFL. The company is directly responsible for the primary structure, the active and passive thermal control, and the development of the internal architecture of these modules. Apparently, Aeritalia is developing the leadership and technology for pressurized modules in Europe.

- **Tethered Satellite System (TSS).** This program is a joint ASI/NASA program. The TSS consists of an instrumented satellite, a thin, flexible tether up to 100-km long, a deployer attached to a spacelab pallet in the space shuttle cargo bay, and scientific experiments on the satellite, as well as in the cargo bay. Two TSS missions are currently planned: (1) an electrodynamic mission using an electrically conducting tether plus satellite deployment spaceward, and (2) an atmospheric mission with the tether and satellite deployed earthward. The first TSS mission is planned for May 1991.

Selenia Spazio was the other major Italian space firm represented. Selenia Spazio is participating in various programs in Europe and the U.S. and is particularly active in telecommunications, remote sensing, and meteorology. In addition, Selenia Spazio is currently involved in the following programs:

- **ITALSAT.** This program is being developed and built for the ASI consisting of a communication satellite operating in the 20/30-GHz frequency band using digital technology and several earth stations for advanced communications and system control. In addition to the 20/30-GHz digital telephony, the ITALSAT will also have these two missions:
 1. The 20/30 GHZ user services with national coverage to experiment with video conferencing, newspaper transmission, high-bit rate connections between computers, and emergency connections
 2. The 40/50 GHZ propagation experiments with European coverage to collect data for use in the design of future operational communications systems.
 - **ARTEMIS.** This is an ESA advanced technology experimental satellite. The ARTEMIS satellite will test and qualify in orbit advanced platform and communications technologies for future missions. The ARTEMIS will consist of three experimental communications payloads:
 1. **Optical Communications Payload (SILEX).** The SILEX payload will be used to carry bidirectional communications in the optical frequencies at a signalling rate of up to 65 Mbit/sec between a geostationary satellite (ARTEMIS) and a Low Earth Orbit (LEO) spacecraft (SPOT 4). The SILEX technology mission also intends to validate the procedures for pointing the optical telescopes installed onboard the spacecraft and demonstrating the on-orbit lifetime of laser-diodes used as transmitters.
 2. **S-band Payload.** This 2,100-2,200 MHz payload will prove the advantages of phased-array technology for electronic beam scanning. The payload includes two separate antennas, both featuring printed circuit radiating elements and active transmit and receive modules.
 3. **L-band Payload.** This payload will allow bidirectional voice-data communications between fixed earth stations and terminals installed on vehicles; e.g., trucks, cars. The key technologies for the L-band land mobile systems includes developing and qualifying large umbrella-type space antennas of approximately 6-m diameter and new solid-state power amplifiers for frequency reuse.
- The ARTEMIS satellite, scheduled for launch in 1994, will also validate some new technologies, such as the ion propulsion subsystem and nickel-hydrogen batteries

made in Europe. It is believed that this spacecraft will be the first unclassified program to use laser optics for space data communications.

Comments

The Paris Airshow is held on alternating years and is considered the world's premier aerospace event and the standard for all aerospace exhibitions. However, the Farnborough International Aerospace Exhibition provides a unique opportunity to meet with many European companies involved in space and establish initial contacts for future site visits. The actual displays and hardware are much less than in Paris because the emphasis in Farnborough is on aircraft and related products and services. Paris, on the other hand, very strongly encourages space participation, which also includes a simultaneous space conference. There was very limited U.S. space participation at Farnborough.

As a final observation, there is a trend for more international joint ventures among European space organizations and companies; e.g., Matra and Marconi merger in space projects and the BAe/Soviet Ministry of Aviation joint study. European companies are also becoming associated with American companies; e.g., McDonnell-Douglas and BAe. and Arianespace and Orbital Sciences Corporation. This could be because of the intense competition for future large international space programs. European research; e.g., hypersonic planes like the German SÄNGER and the associated key technologies, will advance with the creation of large conglomerates; e.g., Deutsche Aerospace, that can afford and can focus its resources. International space cooperation, both in the scientific and commercial areas, will continue, but European space autonomy in manned and unmanned programs is the long-term goal.

BIOTECHNOLOGY

Microbial Adhesion Studies

by Keith E. Cooksey, the Liaison Scientist for Biochemistry, Microbiology, and Marine Biotechnology in Europe and the Middle East. Dr. Cooksey is on leave from Department of Microbiology, Montana State University, Bozeman, Montana, where he is Professor of Microbiology.

Introduction

The Laboratory for Materia Technica is part of the Dental School of the University of Groningen, the Netherlands. This year it is celebrating the 20th anniversary of its formation. The biological adhesion group (10 people) is quite large for such a well-defined subject. However, as is known to people in this field, information arising from particular, fundamental studies of the adhesion and colonization process can be applied generally in other fields. Dr. H. Busscher told me that the group has a 5-year budget cycle and that salaries are included in the intramural budget allocation.

Flow Cell Analysis of Adhesions

The forté of the group is computer analysis of images obtained from microscopic studies of cellular colonization of physico-chemically characterized surfaces. Both bacteria and fibroblasts are studied. The heart of these studies is a flow-cell manufactured from nickel-plated brass. I assumed the construction materials were chosen for ease of machining rather than their inert properties. Some cell lines do not thrive in this flow chamber. I suspect that this may well be a reaction to the nickel coat. The flow cell is equipped with upper and lower transparent windows (approximately 13x5 cm), sealed with O-rings. The main procedural advantages to the cell are that it can be disassembled for cleaning, it allows both laminar and turbulent flow, and the gap between the upper and lower transparent surfaces can be varied using teflon spacers. The transparent windows can be characterized by whatever technique considered necessary, before and after an experiment. For instance, where the windows are made of glass, contact angle measurements showing complete wetting of the surface indicate that the glass is free from hydrophobic contamination before an experiment is initiated. Such measurements are facilitated in this laboratory since they are computer aided. A video image of the contact angle

that the drop of analytical fluid makes with the surface to be tested is used in a curve-fitting program. Thus, the liquid-surface contact angle measurement is generated by the computer rather than by eye using a goniometer. The system can be calibrated using a steel ball in place of the analytical fluid.

Colonization Patterns

Busscher is a strong exponent of the use of flow cells and continuous image analysis over quiescent systems, point sample times, and manual cell counting in microbial attachment studies. He has, however, said in print that he has discovered no principles using his system that were not known before from studies where hydrodynamic parameters were less well controlled. However, as Busscher points out, where the adhesive interaction of the cell with the surface is low; e.g., many types of cells on hydrophobic surfaces, gross artifacts in counting adhered cells can occur. These are caused by rinsing or draining of the colonized surface. In such cases, surface colonization patterns cannot be observed, a subject that is a main thrust of this group. Busscher and his group believe that bacterial cells are not randomly distributed over a surface undergoing initial colonization. I believe that unless a patchiness in distribution is visually obvious, it is hard to prove, even with a computer. As the colonization proceeds, there is less room for each incoming cell on a surface. It is more likely, therefore, to attach to a site near to another cell. Thus a nearest neighbor analysis of the process may suggest cooperativity where none is actually present. However, work from this laboratory has shown that where a surface is subject to flowing liquid, depositing cells are subject to the micro-hydrodynamic efforts of already attached cells, even where the gross flow characteristics are laminar. The onset of macroturbulent flow in the flow cell can be seen visually since cells not firmly attached to the substratum begin to move laterally about their attachment point; i.e., they wobble.

Steps in Colonization of Surfaces

Studies have shown that colonization with some organisms is a two-step process. In the first step, often taking 2 to 3 hours, organisms attaching to the surface follow a saturation curve. After a plateau of about an hour, further increase in cell number takes place, and this is accompanied by secretion of a surfactant by the organisms. In my opinion, this phenomenon is growth related and not necessarily a specific function of metabolism during the colonization process. Such observations of the kinetics of adhesion are much easier to make in an apparatus that allows real-time measurements.

Influence of Adsorbed Materials on Adhesion

In a collaboration with the Center for Biomedical Technology and the Department of Cell Biology at Groningen, Busscher's group is investigating a paradox central to the question about the means by which cells of all types interact with substrata of differing surface chemistry. Why is it that cells adhere differently, both in kinetics and extent, to substrata of differing surface energy when we believe that they are separated from that surface by a layer called the *initial conditioning film*? This film is adsorbed to a surface much quicker than living cells are. Dr. Schakenraad, who works closely with Busscher, referred to the ability of the substratum to "shine through" the adsorbed layer and thus influence the cells. Using adsorbed proteins (fibronectin, albumin) as model conditioning films, these workers concluded that surfaces of differing surface energies caused the protein to adsorb in distinctly different island-like patterns as seen after fixation and examination in the transmission electron microscope. Therefore, in their opinion, the "shining-through" phenomenon is explained partially by the patchiness of the adsorption of the conditioning film--thus leaving some of the substratum uncovered, and the effect of the substratum on the three-dimensional structure of the adsorbed material; i.e., as is usual in biology the answer is not black or white but shades of gray!

The Influence of Shear Forces on Adhesion

A new project in the laboratory involves using the flow chamber to investigate cellular adhesion and detachment as a function of surface shear stress. Populations of fibroblasts were allowed to attach and spread on the glass window of the flow chambers. They were then subjected to an increasing flow rate and thus surface shear force. Before being detached, these mammalian cells rounded up. This project is experiencing difficulty because of the lack of resolution of the optical system used to observe the fibroblasts. I suggested that a Nomarski interference

contrast system would work more satisfactorily than the phase contrast in current use.

Not all the work of the laboratory uses the flow cell, although at least four of these units, together with the analytical systems, were available. Thus, Dr. Cowan, a post doctoral fellow from the U.S., in collaboration with the Catholic University of Louvain, is investigating organisms from the human periodontium. Using a variety of methods, they have found that fimbriate organisms behave differently from capsulated ones and that these differences are evident even within the same culture. Fimbriate cells were positively charged and had high nitrogen/carbon ratios in their surface structures. Negatively charged cells were encapsulated and showed high oxygen/carbon ratios within surface structures. Growth in liquid medium favored the negatively-charged cells.

Are the Adhesive Properties of Cells Taxonomically Relevant?

In taxonomy, organisms with similar names are supposed to be related genetically. Bacterial species often bear names related to their ecological niche which in turn is related to their physiology. Only recently has the adhesion of cells to surfaces become an interest of the microbiologist. Yet, whether a cell has this property is of considerable importance in determining, for instance, its pathogenicity or other aspects of its ecology. Adhesion to surfaces is a multicomponent phenomenon that is not completely understood for any bacterial species. A project directed by Dr. Henny van der Mei is examining the many surface physico-chemical attributes of a series of bacterial strains that may relate to their ability to adhere and comparing these with their traditional taxonomical grouping. Seventeen surface parameters were chosen, including surface charge, hydrophobicity, possession of surface appendages, elemental composition of the surface layers of the cell (by x-ray photon spectroscopy) and infrared spectra of isolates, but as yet no striking correlations have been seen. Statistical analysis of relatedness did show some clustering, however. Streptococcal strains formed one cluster and staphylococcal strains another. One of the greatest problems faced by this study is that all of the methods used measured characteristics of the cells that are related to their physiological state; i.e., the measurements were growth-cycle dependent.

Dental Diseases

Although many of the research projects being carried out in this laboratory were at the fundamental level, at least two involved day-to-day dental problems. With dental caries no longer a serious problem in the Western

world, attention is now being focused on other dental diseases. Recolonization of cleaned teeth by bacteria follows an exponential curve, as it does in heat-exchanger tubes on ships. However, plaque formation slows considerably at night--a situation that does not occur in heat-exchanger tubes! A further component of this study indicates that when one changes the tooth for an intra-oral experimental substratum, surface-roughness plays an important role in increasing the recolonization rate of cleaned surfaces. It was suggested that the role of roughness may even be greater than that of surface-free energy. I think it is important here to realize that in these experiments, the variable of surface roughness was increased from $0.1\ \mu\text{m}$ to $2.2\ \mu\text{m}$ and this provoked a four-fold increase in bacterial colonization rates. These changes are in the critical range of bacterial size; i.e., c. $1\ \mu\text{m}$, thus the situation was changed from one where bacteria were subject to hydrodynamic forces at the surface to one where they were relatively insulated from these stresses. A further increase in surface roughness to say $10\ \mu\text{m}$, would not be expected to increase

recolonization rates further. The plaque forming species collected by intra-oral experimental substrata of differing surface-free energies, were not similar, indicating a selective pressure based on the physical chemistry of the surface.

The last project I visited concerned research at the consumer level. Commercially available mouthwashes were being evaluated for effectiveness in inhibiting plaque formation. Only those that contained antibacterial agents; e.g., chlorhexidine, were effective. No product changed the tooth surface free energy indicating that products containing surfactants (wetting agents) were ineffective.

Concluding Remarks

The interfacial microbiology group at the University of Groningen Dental School is vigorous, with excellent facilities and important collaborative links to other schools in the Low Countries. They are expected to turn their attention to further biofouling projects soon.

COMPUTER SCIENCE

Unified Computation Laboratory

by Armen Gabrielian, Thomson-CSF, Inc., Palo Alto, California.

Introduction

The Conference on the Unified Computation Laboratory was held at the University of Stirling in Scotland, July 3-6, 1990. This was the first conference by the newly created Institute for Mathematics and Its Application (IMA) subgroup on software and computer systems. The conference objective was:

"The systematic study of software development has led to a wide variety of different approaches, theories, concepts, and tools, applicable to each stage in the specification and construction of complex software systems, to a formal view of the development process, and to the evolution of such systems. This diversity is often illusory, and many approaches have a common framework and a common underlying mathematical basis. This conference aims to provide a forum in which to discuss the different approaches and to consider possible unifying frameworks for program construction theories, system structures and the specification design and development of future software construction environments."

About thirty people attended; I was one of four Americans. Other speakers came from Australia, New Zealand, France, the Federal Republic of Germany (FRG), Algeria, Austria, the Netherlands, and the U.K. Six invited and twenty-four regular talks were presented.

In general, the emphasis was on theoretical issues and illustrated the degree to which interest on formal methods in Europe has, perhaps, advanced beyond the level that can be found in the U.S. A British participant suggested that because of concern with the cost of computers in Europe, there has been a greater interest there in methodologies that guarantee the correct use of resources.

In particular, the International Standards Organization (ISO) has influenced establishing standards for communication and specifying communication protocols in Europe. While this might be perceived as a limitation on creativity, it apparently has not caused much

constraint on the extensive research on specification methodologies in many universities and research laboratories. Much of this goes far beyond the ISO standards. Even in an industrial setting, a significant milestone was achieved recently. Conformance was verified of the floating point arithmetic unit of the T800 transputer chip with the Institute of Electrical and Electronics Engineers (IEEE) Standard 754 at the British firm INMOS, Ltd. (a subsidiary of the Italian-French joint venture SGS-Thomson). The verification was actually performed in collaboration with an Oxford University team. As a result, the two groups received the Queen's Award for their work in 1990.

Only extended abstracts were distributed at the conference. Oxford Press will publish the full papers. In the following sections, I have summarized some of the key concepts that were presented in several major areas.

Algebraic Construction of Compilers

In an invited talk, Professor Teodor Rus, University of Iowa, presented a tutorial on his research on algebraic construction of compilers and demonstrated the system Technology for Implementing Computer Software (TICS) that implements his methodology. Conventional compilers are too complex because of concern for semantics of languages and the added concern for an intermediate language. In addition, it is not easy to modify conventional compilers to take advantage of parallel architectures. In his approach, the source language and the target language are defined as algebraic structures with a homomorphic mapping that defines the translation from the former to the latter. Thus, the issue of the semantics of the languages disappears! Only Pascal-like languages were considered, but apparently the technique is quite general. However, certain assumptions seem to have been made about the nature and the use of languages that allows him to define his compilers in terms of seven characteristics of concrete computational entities (CCE) such as program statements, variables, and constants. Table 1 shows the characteristics.

Table 1. Concrete Computational Entities Characteristics

- Standard - Data or operation
- Manner of usage or mode - Locally defined and used, locally defined and globally used, globally defined and locally used, and globally defined and used
- Type of value - Real or integer
- Representation
- Entry point - Start of program
- Exit point - End of program
- Results.

Not all characteristics are necessary for each CCE. Defining a compiler then becomes somewhat like specifying the rules of an expert system. The advantages are that it is easy to construct compilers for a new language, and presumably parallel architectures can be accommodated and various optimization strategies can be specified. In the TICS system, the definition of these characteristics is stated interactively and within a few minutes, a compiler for a fragment of a new language can be constructed.

Protocol Specification Formalisms

M. Bettaz, University of Constantine, Algeria, presented some preliminary results on a generalization of numerical Petri nets, with application to modeling communication software in the open system interface (OSI) framework. The Petri net concept, of course, is widely used in Europe, despite its deficiencies. Numerical Petri nets are a variation of multicolored Petri nets in which each token is a tuple. In his generalization, the tokens can be terms from an algebra. The application of these concepts to specification of real-time systems (which interests me) is apparently only beginning to be considered by some of the associates of Bettaz.

G.H.B. Rafsanjani, British Telecom Research Laboratories, presented two papers on the "Language of Temporal Ordering Specification (LOTOS)." The LOTOS is one of the three standardized formal description techniques (FDT) accepted by ISO. The others are specification and description language (SDL) and Estelle. The SDL is an older language that is essentially equivalent to finite-state machines. In Estelle, a system is described in terms of a hierarchy of communicating modules which represent extended finite-state machines and communicate through infinite first-in-first-out (FIFO) queues. The language LOTOS is more powerful than Estelle, according to Rafsanjani, and is the standard being used at British Telecom. The LOTOS specifications utilize two formalisms: (1) data is specified in terms of the ACT ONE abstract data type language, and (2) processes are specified in terms of a process algebra based on Milner's Calculus of

Communicating Systems (CCS) and Hoare's Communicating Sequential Processes (CSP).

The main issue of concern at British Telecom is that LOTOS specifications are difficult to understand. In addition, the ISO LOTOS document is too complex and the language is not executable. Rafsanjani's main goal has been to convert LOTOS specifications to Petri nets so engineers will have a visual method of understanding specifications and can simulate and analyze systems. His main result was to show that the recursive aspect of LOTOS cannot be translated into Petri nets, since it would require potentially an infinite number of transition from a place. Some recent work on hierarchical Petri nets may provide a solution, but this work is of a very preliminary nature and has not been formalized in detail.

In a separate presentation, R.G. Clark, University of Stirling, also confirmed the difficulty of using LOTOS. He also discussed some conventions and constraints that he has developed for simplifying its use. He articulated the difference between "requirements-oriented" and "design-oriented" specifications, saying that LOTOS can be used for both but concentrating on the latter. In discussing real-time specification, he said that LOTOS provides no special built-in features to handle time; it deals mainly with temporal ordering of events. However, one can construct special data types to represent time and duration. This is generally considered unsatisfactory and is very much like creating a variable to represent time in standard logic, in contrast to defining time as a primitive concept as in temporal logic.

Real-Time System Specification

In my talk on the Office of Naval Research-sponsored research at Thomson-CSF, Inc., I presented some recent work on a framework, called "Hierarchical Multi-State (HMS)" machines, that integrates automata theory and temporal concept logic for specifying real-time systems. The HMS machine provides a graphic formalism and an equivalent formal language in which both design and requirements can be specified in a uniform manner. The main new results were

- Defining a new temporal interval logic (TIL) that generalized our former more limited language for specifying temporal constraints
- Formalizing hierarchies, recursive hierarchies, and composition of asynchronous HMS machines
- Applying model-checking to verify properties of HMS specifications.

The important benefits are that

- Complex temporal constraints can be specified more simply
- Real-time abstract data types, distributed, and loosely coupled systems can be specified precisely

- Two methods of verification are available for HMS machines.

An earlier method based on correctness-preserving transformations was presented at the IEEE Real-Time Systems Symposium in 1989.

In a survey talk, N.J. Wilson, City College, Norwich, U.K., reviewed various temporal logic methods in system development. He reviewed the distinctions between linear- and branching-time logics, safety, and liveness properties. Also, he discussed the notions of precedence and fairness. Some of the best-known temporal logic languages proposed are TEMPLOG by Abadi and Manna (extends a Prolog-like language to include temporal operators), TEMPURA by Moszkowski, and TOKIO by Fujita et al. In discussing Misra and Chandy's UNITY concept, two issues were presented. First, it was pointed out that it is difficult to implement the UNITY approach. Secondly, there appear to be some efforts to circumvent the fundamental notion of nondeterminism in UNITY. In particular, in a separate presentation, D. Mery, Centre de Recherche en Informatique de Nancy (CRIN) which is associated with Centre Nationale de la Recherche Scientifique (CNRS) in France, described how mechanisms for defining control information have been added to an implementation of UNITY.

Abstract Algebra and Category Theory

Eric G. Wagner, IBM T.J. Watson Research Center, Yorktown Heights, New York, presented an invited talk entitled, "Some Mathematical Thoughts on Languages for Data Directed Design." His main goal was to present a formal framework, expressed in a language called LD, for designing languages of an object-oriented flavor. His observations were:

- In Smalltalk, an object has a value that is either a primitive object or a tuple of objects. The expressive power of the language can be enhanced if one allows an object to have as values a set of tuples.
- We don't need primitive objects, provided we allow recursive objects.
- Mathematically, it is undesirable to have the empty set as a value.
- We really want to work with "class-systems" rather than individual classes. For example, we need operations such as $NAT \times NAT - BOOL$, that involve several classes.
- Relationships among classes need not be partially ordered. Symmetric dependencies can be useful.

These ideas and some new approaches to method calling and inheritance are accommodated in Wagner's LD language.

M. Johnson, University of Sydney and Macquarie University, Australia, made two presentations on the applications of higher-order category theory. In the first talk, he presented some preliminary work on category-theoretic description of the syntax and semantics of the entity, relationship, attribute (ERA) approach to database specification. The structure of objects, attributes, and relationships are described in terms of a "static category." The update operations on the corresponding database are described in terms of a "dynamic category." One of his goals was the formal specification of constraints on specifications. Apparently, enough practical potential has been proven of such a formal approach to make Telecom Australia fund some of this research.

In his second talk, Johnson discussed using category theory in formalizing term rewriting systems. A rewriting system consists of a set of rules that allows one to substitute a substring by another substring repeatedly. Rewriting systems have applications in automatic theorem proving, computational algebra, polynomial ideal theory, and general models of computation. Term rewriting is a generalization in which terms of an algebra are rewritten, with substitution of arguments permitted. The main point of the talk was to demonstrate that by using two-categories a simpler characterization of term rewriting systems can be provided. In particular, the commutativity of certain rewrites can naturally be expressed in terms of commutative diagrams. An example of a term rewriting system is $f(x(f(y,z))) \rightarrow f(f(x,y),z)$, which is often called the associativity rewrite. The representation of term rewriting systems by higher-order categories essentially reduces them to a two-dimensional string rewriting systems and questions such as determining local confluence can be investigated more simply. For a survey of term rewriting systems, the following might be consulted: J. Avenhaus and K. Madlener, "Term Rewriting and Equational Reasoning," in *Formal Techniques in AI: A Sourcebook*, R.B. Banerji (ed.), Elsevier Science Publishers (North Holland), 1990, Amsterdam, pp. 1-43.

In an invited talk entitled, "Inductive Reasoning for Completing Equational Software Specifications," K.P. Jantke, Leipzig University of Technology, FRG, discussed further applications of rewriting systems in transform complete axiomatic specifications to incomplete but executable specifications. He used methods similar to the Knuth-Bendix completion, sometimes ending with an infinite number of rewrite rules.

Intuitionistic Logic and Martin-Lof Type Theory

Three talks were presented on this highly theoretical area. D. Galmiche, CRIN, University of Nancy, described some developmental exercises that utilized a combination of different theoretical concepts. C. Horn, Humboldt University, Berlin, presented seemingly impressive results on a system called Oyster for theorem proving and program synthesis based on Martin-Lof type theory. A. Hamilton, University of Stirling, described and demonstrated his Programs and Proofs in constructive type theory (PICT) system that is also based on Martin-Lof type theory. During this demonstration, PICT took 40 steps to prove that $A \& B \rightarrow B \& A$. Hamilton indicated that the most complicated problem that he has considered so far is the proof of the commutativity of addition which took 255 steps.

Prototyping and Formal Specification at LRI, Université Paris-Sud

In two invited talks, Christine Choppy and Michel Bidoit described two large and seemingly independent efforts at Laboratoire de Recherche Informatique (LRI). Choppy discussed her work on program testing, automatic test generation, formal specification, validation, and prototype creation. In her project, she uses a variety of tools and techniques. She is concerned with local and global correctness when a set of programs are integrated. In software reuse, she is concerned with describing what a program computes and wants to deduce that, for example, if an identifier in a program is changed, its semantics will remain intact, assuming no conflicts with other identifiers. Also, a mixture of specification and partial or incomplete module

implementations are accommodated in her system. Bidoit's talk was entitled, "Development of Modular Specifications by Step-Wise Refinements Using the PLUSS Specification Language." His viewpoint is that specification is the final product. In particular, he is interested in developing a specification, noting that creating a specification for a large system is complicated. Modularity is a key concept in the PLUSS system. He imposes constraints on modules and extensions to them to make subsystems more interchangeable. The overall impression was that in the PLUSS system, an attempt has been made to establish an accommodation between some highly algebraic concept and some practical consideration in constructing software. Some extensions to PLUSS apparently have also been made to allow the specification of concurrent processes and real-time aspects.

Conclusions

The conference confirmed my introductory comment that an extensive amount of effort is being expended in Europe at this time on studying formal techniques for specifying, designing, and implementing systems and software. Admittedly, some of these efforts are so abstract and impractical that little short- or long-term practical impacts should be expected. Also, there is much more of a tendency to embrace a standard methodology regardless of its shortcomings. On the other hand, a strong feeling of cooperation seems to exist in different countries, partly because of the requirements and influence of the European Strategic Programme for Research and Development in Information Technologies (ESPRIT) program and partly because of the standardization efforts at ISO.

INFORMATION TECHNOLOGY

Formal Methods and Tools for the Development of Distributed Real-Time Systems (SPEC)

by Robert D. Ryan, a mathematician currently serving as a Liaison Scientist for Mathematics and Computer Science in Europe and the Middle East for the Office of Naval Research European Office. Mr. Ryan is on leave from the Office of Naval Research Arlington, Virginia, where he is Director of the Special Programs Office.

The first annual review of the European Strategic Programme for Research and Development in Information Technology (ESPRIT) Basic Research Action Number 3096, Formal Methods and Tools for the Development of Distributed Real-Time Systems (SPEC), was held at Oxford University on September 24-27, 1990. I was invited to attend all of this review except for the private discussions with the official reviewers and the business meetings. I count this a unique opportunity because it gave me both an up-to-date view of a major ESPRIT Basic Research Action and insight into the management of an ESPRIT project. I will discuss both of these aspects of SPEC. Readers not familiar with ESPRIT or the ESPRIT Basic Research Actions are referred to ESNIB 90-06 for a general description and to ESNIB 91-01 for brief descriptions of the Basic Research Actions in computer science.

SPEC - Motivation and Description

The SPEC action is motivated by the challenge of building distributed real-time systems. The participants cite the intense research activity in the computer science community that has produced a group of specification formalisms and associated development and verification tools. These include temporal logic, automata, process algebras, and assertional methods, each of which has been used with some success on relatively small problems. All of these formalisms have deficiencies, and the deficiencies become real inadequacies when faced with large, complex systems with real-time constraints. The goal of this action is to alleviate these deficiencies and to provide frameworks for the specification and development of distributed real-time systems that are both practically adequate and theoretically sound.

The approach is based on the premise that the deficiencies in current formalisms tend to be complementary and that combining these formalisms can

be very effective. In addition, SPEC research proceeds in two other directions: broadening the scope of present formalisms and narrowing the gap between specification and executable code.

In the current context, combining formalisms means the combination of a transition-based formalism, such as a finite-state automaton or a process algebra, with a logic-based formalism such as temporal logic. The idea is that transition-based formalisms are ideal for describing local sequencing requirements, while logic-based formalisms are well suited for the representation of global requirements and constraints, in particular, timing constraints.

Broadening the scope of existing formalism means, first of all, the ability to handle real time. Additionally, the SPEC participants are planning other extensions to genuinely distributed models of computation (for instance models including asynchronous communication) and to models containing probabilistic information. The latter is motivated by the desire to deal with reliability issues.

Narrowing the gap between formal specification and executable code progresses along two complementary lines. The first effort follows the development paradigm whereby one starts with a formal specification, and then, by a sequence of transformations, refinements, reductions, and simplifications derives an efficient implementation of a program that (provably) satisfies the original specification. The second line of research strives to eliminate the traditional dividing line that exists (at least in logic-based approaches) between specification and implementation languages. The idea is to identify an executable subset of the specification language so that the passage from a declarative specification to an imperative implementation proceeds as a sequence of transformations within the same formalism. Encouragement for this unified approach is provided by

success in the sequential case, as illustrated for example by Prolog.

SPEC - Membership and Management

The main contract is with Eindhoven University of Technology (EUT), the Netherlands, and the project coordinator at the time of this review was Professor Willem-Paul de Roever of EUT (de Roever has since moved to the University of Kiel). The other participants are:

- The Programming Research Group (PRG), Oxford University, U.K.
- University of Manchester (MU), U.K.
- Imperial College of Science, Technology, and Medicine (ICSTM), London
- Institute of Computer Science Crete (ICSC)
- Swedish Institute of Computer Science (SICS), Kista, Sweden
- University of Liège (ULG), Belgium
- University of Nijmegen (KUN), the Netherlands
- IMAG Grenoble (IMAG), France
- The Weizmann Institute of Science (WEIZ), Rehovot, Israel.

The individual project leaders are:

- | | |
|---------|---------------------|
| • MU | Howard Barringer |
| • ICSTM | Dov Gabbay |
| • ICSC | Costas Courcoubetis |
| • PRG | Mike Reed |
| • IMAG | Joseph Sifakis |
| • ULG | Pierre Wolper |
| • KUN | Martin Wiecezorek |
| • WEIZ | Amir Pnueli |
| • SICS | Bengt Jonsson. |

I have not seen a detailed description the contractual requirements placed upon the ESPRIT Basic Research Actions, however, several aspects of the management and reporting are clear from the ESPRIT documentation and from the conduct of the review. The project coordinator has considerable responsibility for collecting information from the participants and preparing an annual report. This first annual report on SPEC, known officially as Periodic Progress Report 1 and covering May 1, 1989 - April 30, 1990, provides a comprehensive picture of the participants' research, collaboration, and other activities associated with SPEC. Section headings include

- Major Milestones Achieved and Deliverables Produced in the First Year
- Major Milestones Missed, with Reasons Why, and Corrective Action Taken
- Other Significant Achievements and Problems
- Internal Collaboration
- Contacts with Other Actions and ESPRIT Projects
- Other Contacts.

There is a large section called "Work Part Summaries" which contains for each participant (and the coordinator) a task-by-task description of the research, including a bibliography. There is also an interesting section entitled "Update on the Worldwide State of the Art." This section contains brief notes about related work outside of SPEC with references to recent literature. Finally, there is a section called "Deliverables Overview" that contains a formatted description of each deliverable. The format contains, in addition to the obvious identifiers, the following fields. My comments are in square brackets.

Description of the Deliverable

[The entries here for a BRA project are mostly reports. The entry will typically contain the title, authors, and a very brief description of the work.]

Partners Contributing

[Typically only one partner is listed. Most papers are written within one institute.]

Description of Expected Further Use Inside the Action

[This will often be an indication of relevance to other work in the BRA.]

Outside the Action

[This typically indicates relevance to other government or industrial programs.]

Impact of Deliverable (actual or expected)

(Publication, Product, Contribution to Standard, Technology Transfer, etc.)

[This is often a brief statement about where the paper will be published and the impact of the work on the field.]

Expected to be Relevant to ESPRIT Project

Number or B.R. Action Number

[This is a list of other relevant ESPRIT activity.]

Has Been Made Available to Organization:

[This field is almost always empty. The two I found with entries contained places like British Petroleum, Inmos, and Philips Research Laboratories.]

I have included this material because I believe it says something about the ESPRIT objectives and about the management of this and other ESPRIT Projects and Basic Research Actions.

SPEC - Research Results

I believe that the best way to present the scope and richness of the first year's results is to use the same organization that de Roever uses in the annual report. He presents major milestones achieved under the following 6 headings:

1. Models for concurrency, reliability, and timing
2. Specification formalism, interrelations, and combinations
3. Theories of verification and refinement
4. Executable subsets of specification formalisms
5. Tools and supporting environments
6. Applications.

This list suggests a hierarchy with the lower ones being dependent upon the upper ones. But as de Roever points out, the topics are closely interconnected. For example, verification and refinement theories influence the way one constructs specification formalisms, and applications clearly influence theories, formalisms, models, and tools. The following accomplishments are taken from the annual report.

1. Models for concurrency, reliability, and timing. Advances have been made with respect to the characterization of timing in specification mechanisms.

(PRG) Timed CSP has been extended with channel communication, enabling the classification of pathological behavior in timed communication, and the use of this classification to derive useful laws for chaining and buffering (Schneider, 1990).

(EUT) In the past, the research done at EUT on distributed systems assumed that the system was, at least conceptually, globally timed. Now they have dealt with the case that processors have local clocks. They have related the clocks to each other in order to establish real-time properties of these systems. This result has been applied to the semantic modeling of a Very Large Scale Integration (VLSI) specification language (Roncken and Gerth, 1990).

(EUT) In his Ph.D. thesis, C. Huizing has developed a common framework in which the semantics of various specification formalisms for reactive and real-time systems, such as Esterel and Statecharts, can be described and evaluated (Huizing, 1990).

2. Specification formalisms, interrelations, and combinations. Among the major accomplishments are analyzing realizable specifications, separating those specifications that can be implemented from nonimplementable ones, and introducing time in process algebras. Advances have been made in specifying an intuitionistic executable temporal logic for designs, in specifying reliability, and in developing a simple Statechart-like language, which removes some of the semantic complexities of the full Statechart language.

(ICSTM) Gabbay and others have developed an intuitionistic executable temporal logic called RDL. This was a result of collaboration with MU, and they have related it to the work on design and specification at KUN (Gabbay et al. 1990, two papers).

(SICS) Hansson and Jonsson have developed a formalism called PCTL for stating properties such as, "after a request for service there is at least a 98 percent probability that the service will be carried out within 2 seconds." They also have a method to check that a system satisfies such properties. (Hansson and Jonsson, 1989)

(SICS) Hansson and Jonsson are currently developing a process-algebraic formalism for describing distributed systems together with real-time and reliability aspects.

This is an extension of Milner's Calculus of Communicating Systems with time and probabilities (Hansson and Jonsson, 1990). This complements the work at IMAG on ATP and the work at PRG on Timed CSP.

(WEIZ) Pnueli and Rosner have formulated a general framework for the synthesis of programs from their specifications, given in temporal logic. This was first done for synchronous systems (Pnueli and Rosner, 1989a) and later for asynchronous systems (Pnueli and Rosner, 1989b). They have also worked on the problem of distributed synthesis; i.e., synthesizing a program to fit a prescribed architecture. They discovered that this problem is undecidable for most nontrivial architectures. A preliminary report on these results, including decidable cases, is given in (Pnueli and Rosner, 1990).

(IMAG) The ATP is a process algebra for the description and analysis of timed systems. This algebra has a distinguished element in its vocabulary of actions that is a time event representing progress of time. This algebra complements the approach of the PRG (Nicollin et al., 1990).

(IMAG) The ARGOS is a graphical language whose syntax relies on the higraphs formalism of David Harel and whose semantics is defined in terms of a process algebra (Maraninchi, 1989). This work complements the efforts of WEIZ and EUT on the definition of graphical specification languages for reactive systems.

(KUN) Wieczorek and Vytupil define a basic version of RDSL, a formal specification language in (Wieczorek and Vytupil, 1990a). In (Wieczorek and Vytupil, 1990b) they extend RDSL in order to reason about reliability, thus providing a vehicle for reasoning about hard real-time systems.

(ULG) These people have been studying the interaction between temporal logic and automata specifications. Their main result is a criterion for distinguishing between combined specifications that make sense and those that do not. The criterion is basically that a specification makes sense if it can be implemented in any environment. This notion is called realizability and an algorithm for checking if a given combined specification is realizable has been developed in (Abadi, et al., 1989).

3. Theories of verification and refinement. Major accomplishments include the work on refinement of timed and concurrent programs and the work on proof systems for real time. Advances have been made on proof systems for proving liveness properties in a temporal partial order framework and on verification of multiprocess programs.

(SICS) Jonsson has presented methods for establishing that one specification of a distributed system is a correct refinement of another specification (Jonsson,

1990a). This is a simple and clarifying treatment that builds upon work in (Abadi and Lamport, 1988 and 1990).

(SICS) Brinksma, Jonsson, and Orava are working on the problem of refining interfaces between components of a distributed system, a major open problem in the theory of refinement for distributed systems (Brinksma et al., 1990). This relates to the work on action refinement at EUT.

(WEIZ) A proof system for proving liveness properties in a temporal partial order framework has been developed and applied to specify serializable databases (Peled and Pnueli, 1990).

(WEIZ) Manna and Pnueli have developed special verification methods for reasoning about systems consisting of a family of similar processes in a uniform way (Manna and Pnueli, 1989). The setting is multiprocess programs that are programs consisting of many similar processes. The problem posed for these systems is that of uniform verification, that is, proving properties that hold for such a system, independently of the specific number of processes.

(PRG) Recent work on Timed CSP has concentrated on behavioral specifications, that is, properties that must hold for all possible behaviors of a process. Timed CSP processes can be described in an appropriate process algebra, and their conformance to behavioral specifications can be verified by using the proof system given in (Davies and Schneider, 1990). A temporal logic for Timed CSP is described in (Jackson, 1990).

(PRG) This group has developed a theory of timewise refinement whereby correctness results in timed models of CSP can be established by analyzing the image of timed processes under mappings onto untimed models. For example, if an untimed process is deadlock-free, then any timewise refinement of it is deadlock-free. See (Reed, 1990) and (Schneider, 1990).

(EUT) Gerth has grounded the theory of refinement of first order programs in the theory of process algebra (Gerth, 1990).

(EUT) In the past, EUT has developed an extensive theory for the compositional verification of programming languages for real-time distributed systems with synchronous value communication, such as occam, against assertional specifications. This theory is currently being extended to take multiprocessing and hardware constraints into account. Feeling the need to firmly consolidate the existing theory, EUT has tried to establish a solid basis in the form of soundness and (relative) completeness results for two proof systems that they have developed. The first uses real-time temporal logic as specification language (Hooman and Widom, 1989); the second is based on Hoare-triples (Hooman and de Roever, 1990). Hooman attempts to relate these two approaches in (Hooman, 1990).

4. Executable subsets of specification formalisms.

The introduction of the new programming paradigm, executable temporal logic, is clearly a major accomplishment. Another important result is that Boolean Lustre can be merged with an executable linear temporal logic.

(MU & ICSTM) Work at MU and Imperial College has led to the development of a theoretical framework for executable temporal logic. This is called MetateM and is described in (Barringer et al., 1990a). In (Barringer et al., 1990b), the authors investigate the issues of what metalanguages are, how to translate between meta and object levels, and what it means for a language to be its own metalanguage.

(MU & ICSTM) A prototype implementation of MetateM has been produced. The prototype is written in Scheme and has been used to experiment with various temporal logic programs and different execution strategies (Fisher, 1990).

(IMAG) Researchers at IMAG have shown that Boolean Lustre programs correspond to formulas of a linear temporal logic called "safety logic," which allows safety properties to be expressed. They have shown that safety logic has the same expressive power as prefix closed regular languages (Bouajjani et al., 1990a). Starting with a given formula in this logic, it is possible to generate a (maximal) model, which is an automaton accepting the language representing the characteristic set of the formula. The method for generating this model leads naturally to an on-the-fly verification method by model checking (Halbwachs, 1990).

5. Tools and supporting environments. The highlights include various developments in real-time model checking, advances in the verification of large systems, and efficient computational procedure for computing the worst-case probabilities in probabilistic verification.

(ICSC) Alur, Courcoubetis, and Dill have introduced a model for model checking of real-time systems that consists of a finite-state transition graph and a finite number of continuous-time clocks. The transitions of the graph are enabled by simple predicates on the values of the clocks, and the clocks are reset by some appropriate transitions. The logic in which they describe timing requirements is a variation of CTL which extends temporal operators to reason about continuous time. They reduce the model checking of such systems to model checking for finite-state structures and provide the corresponding algorithms (Alur et al., 1990).

(ICSC) Courcoubetis and Yannakakis have studied the behavior of systems which have partly nondeterministic and partly probabilistic behavior. Such systems are appropriate models for communication protocols or manufacturing plans. They investigate the effect of nondeterminism on the expected behavior of the

systems, and they derive optimal strategies for maximizing the probability of some desired behavior (Courcoubetis and Yannakakis, 1990).

(SICS) Jonsson has done some work on automatic verification of finite-state systems that communicate via unbounded first-in-first-out channels (Jonsson, 1990b).

(WEIZ) Harel, Lichtenstein, and Pnueli have developed a model and a temporal logic, Explicit Clock Temporal Logic (XCTL), for the expression of timing properties of reactive systems. They have developed algorithms for checking general validity and validity over a given program (model checking) of the propositional version of the logic (Harel et al., 1990).

(WEIZ) Sherman and Pnueli have investigated efficient implementations of the satisfiability and model-checking algorithms. Certain optimization and preprocessing steps incorporated in the program provide performance efficiency (Sherman and Pnueli, 1989).

(WEIZ) Chandy, Sherman, and Pnueli have implemented the algorithms described above on a parallel machine similar to a hyper-cube. These experiments show that model checking is one of the problems where parallel computation can result in close-to-linear speedup (Chandy et al., 1989).

(IMAG) Graf and Steffen have given a method for compositional minimization of systems of communicating processes. The work is motivated by model checking for these systems and a desire to control state explosion (Graf and Steffen, 1990).

(IMAG) Bouajjani, Fernandez, and Halbwachs have developed on-the-fly algorithms for minimizing state spaces for finite automata, with a view to application in model checking (Bouajjani et al., 1990b).

(ULG) Wolper and Lovinfosse have developed a simple inductive method for the verification of large sets of identical processes. This method is based on the concept of network invariant. In simple terms, a network invariant is a process that stays unchanged under composition with the replicated part of a network of processes (Wolper and Lovinfosse, 1989).

6. Applications.

(PRG) Timed CSP has been applied to several real problems, including the design of aircraft engine control software (Jackson, 1989), real-time robotics, and a formal specification of the Greek telephone switching network.

(EUT) Stomp and de Roever have given a correctness proof for a distributed network protocol, namely, the distributed spanning tree algorithm by Gallager, Humblett, and Spira (Stomp and de Roever, 1989).

(EUT) For the derivation of a real-time distributed watchdog algorithm see (Hooman and de Roever, 1990) and (Hooman and Widom, 1989).

SPEC - Industrial Day

An Industrial Day is a feature of each ESPRIT BRA annual review. Invitations are sent to industrial researchers "who could provide feedback on the suitability of the research results for addressing industrial problems." To my knowledge, Jean-Christophe Madre from Groupe Bull and I were the only "industrialists" at this first SPEC annual review.

The SPEC managers elected to focus on synchronous languages for the development of real-time embedded systems. For this they invited three well-known experts to give presentations: Professor Gérard Berry (the founder of Esterel, from École des Mines, Sophia-Antipolis, France), Professor David Harel (the inventor of Statecharts, from WEIZ), and Dr. Nicolas Halbwachs (one of the original inventors of Lustre, from IMAG, Grenoble).

Professor Berry presented an overview of the language Esterel (Berry and Gonthier, 1987), which was historically the first synchronous language (Berry et al., 1983). He talked about Esterel: the concept, the language, and the tool set, and avoided discussion of the programming primitives. Berry emphasized the usefulness of the concept of perfect synchrony for dealing with reactive real-time systems. He contrasted the determinism of Esterel and its advantages for debugging with the nondeterminism of asynchronous languages. Professor Berry spent considerable time discussing the implications of perfect synchrony, including instantaneous communication (broadcasting), instantaneous decisions, and simultaneity of events. The assumption is that of infinitely fast execution. All of this leads to exact temporal reasoning and separation of temporal concerns, a great advantage in many situations. Regarding the assumption of perfect synchrony, Berry was quick to point out that the validity of the assumption, and consequently the validity of using Esterel, must be decided in each case. He also discussed the temporal paradoxes that can be generated by the synchrony hypothesis. These are analogous to short circuits or oscillations in electronics and to deadlock in asynchronous parallel programs. These temporal paradoxes are statically detected by the Esterel compiler. Generally speaking, they occur whenever the input of a program depends upon its output.

Esterel is an efficient, imperative-style language. The language is mathematically well defined, its semantics being given by a set of rewrite rules à la Plotkin (Plotkin, 1981). Esterel programs are translated into automata. This has the advantage of permitting automatic proofs of properties of the resulting automata. Since the resulting code depends upon the size of the automaton, considerable work has and is being done on optimization at the object code level. Professor Berry concluded that

Esterel is a full fledged programming language (it is not a specification language) with well-defined semantics. The compiler is efficient and generates efficient code, and there exists a comprehensive set of tools. Users indicate that it is not particularly easy to write programs, but that the programs have very good readability and confidence. They emphasize the importance of simulation and verification and the importance of having both concurrency and determinism. They also say that Esterel is much less tolerant than a specification language. Users include AT&T and Institut National de Recherche en Informatique et en Automatique (INRIA) for protocols, AMO for avionics, IMRA in Japan for the auto industry, Matra in France for the Paris metro, INRIA for robotics, and DEC for circuits.

The talk by Professor Harel was different in tone and content from that of Professor Berry. Whereas I had planned to hear a talk on Statecharts, what we heard was a general talk on software engineering from an historical perspective, with an emphasis on tools, their performance today, and what they can and should do in the future. The title of Professor Harel's talk was Biting the Silver Bullet--Specification Gridlock: The Root of the Problem. The "Silver Bullet" refers to a paper by Fred Brooks entitled No Silver Bullet. This is a fairly pessimistic view of software engineering in which Brooks argues that the "proposed solutions" to the software problem are not silver bullets. Among these nonbullets, Brooks lists high-level languages, object-oriented programming, artificial intelligence, automatic programming, graphical programming, program verification, and hardware improvements. Brooks' advice is to buy software, refine requirements using prototypes, and find and cultivate extremely talented people.

Professor Harel took a more sanguine position and argued that the grand sum of many these innovations has worked wonders. He contrasted what we have and can do today with the situation not too many years ago, which, to borrow an aviation metaphor, could be characterized as "one man, one fan." Harel pointed out that we have made great progress since the days of the individual programmer and execution by hand. He continued by declaring that a "vanilla" framework of "goodies" was emerging. These "goodies" referred to the capabilities of CASE tools. Harel emphasized the importance of visual formalisms and executable specifications, providing the possibility for extensive simulation. He predicted that tools without extensive execution and codification abilities would disappear, and that tools with these abilities would be available within 8 years. In addition, these tools would provide automatic verification of larger systems and optimization of code. At several points in Professor Harel's talk, someone made reference to Statecharts and to StateMate, the Statecharts tool marketed by David Harel and Amir Pnueli. In each case,

Harel indicated that he was not making reference to StateMate, but to the state of the art generally. Nevertheless, I still had the feeling that part of the message was that StateMate would be one of the tools providing the "goodies" 8 years from now.

Dr Nicolas Halbwachs rounded out the synchronous language story with a talk on Lustre. Lustre is a synchronous, data-flow language related to Lucid (Wadge and Ashcroft, 1985). A program is made of equations specifying identities between flows, where a flow is a sequence of values together with a clock specifying the sequence of instants when these values appear. Thus, Lustre is a functional (declarative style), synchronous language for specifying, programming, and verifying real-time systems. Halbwachs indicated that Lustre is in the first place a programming language, but it is formal enough to be extended towards a specification language. Thus, the same concepts are used in the program and in the expression of the desired properties. The Lustre compiler generates a finite automaton that can be used for verifying logical properties by model checking. In particular, safety assertions, which are written as part of the code, are checked at compile time.

As in Esterel, the synchrony hypothesis is central to Lustre. Once again, it is the responsibility of the user to be sure that a program will be executed faster than the time between external events. If not, consistency can be lost.

SPEC - Comments

Briefly stated, the SPEC goals are to broaden the scope of formalisms, narrow the gap between specifications and executable code, and combine formalisms advantageously. How well are they doing? I believe very well. The project is making significant progress on all three goals, particularly on the first two. I base this opinion on the research results from the annual report presented above. For example, the work on Timed CSP at Oxford, the extension from global to local clocks at EUT, the extension of CCS with time and probability at SICS, the extension of RDSL for reasoning about hard real-time at KUN, and the work on ATP at IMAG--all of this work broadens the scope of formalisms.

The gap between specifications and executable code is being narrowed by, for example, the results on executable temporal logic from MU and Imperial College, the extensions of the work by Abadi and Lamport done at SICS, and all of the work described above leading to more efficient model checking, refinement, and verification.

In my opinion, results are somewhat thinner when it comes to combining formalisms. The work at Eindhoven on a common framework for the semantics of several specifications formalisms, the work at IMAG on a

process algebra for the description and analysis of systems of timed processes, and the work at ULG on the interaction between temporal logic and automata specifications are steps in this direction. There are other results that one can put under this objective, but, for me, they do not resonate as do the results under the first two stated objectives.

What about collaboration? This is one of the ESPRIT policy objectives. It appears to me that there is very active collaboration within subsets of the SPEC participants, and, in fact these subsets are called "circles." The strongest collaboration is clearly between MU and Imperial College. They act almost as a unit in this BRA. From what I observed at the review and read in the annual report, and based upon my experience in encouraging collaborative efforts at the Office of Naval Research, I give this project high marks.

What about the future? I believe that probabilistic constructs will increasingly be combined with the various formalisms. This is already happening at Oxford with CSP, for example. This research is being driven by the need for reliable systems and formal support for thinking about fault-tolerant systems. I expect to see more work in the area of executable specifications. Finally, I do not believe that we will see great unification or integrations of formalisms. These umbrellas will tend to fall under their own weight. I expect a multiplicity of methods will survive, each developed and honed for a specific set of applications. There may not be a silver bullet, but there will be a good selection of steel jackets to get the job done.

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MATERIALS

Synthesis of New Explosives and Binders within the New U.K. Defence Research Agency

by R.W. Armstrong, University of Maryland, College Park, (currently on sabbatical leave at Cavendish Laboratory, University of Cambridge, U.K.)

Introduction

A 1-day meeting organized by the Energetic Materials Research Committee (EMRC) was held at the Royal Armament Research and Development Establishment (RARDE), Waltham Abbey, on October 2, 1990 (just before the facility closed). Eighty persons attended the meeting, representing nineteen organizations. The topic was mostly related to chemical synthesis of binder systems, but also covered some consideration of explosives and propellant composite properties.

G. Hooper, Head of RARDE, Waltham Abbey, welcomed the attendees. Then C.H. Oxlee, Deputy Director of Armament, spoke about the new (as of April 1991) Defence Research Agency (DRA) structure, which now reports to a Chief Executive directly responsible to the Secretary of State for Defence. The new structure also includes the remaining units of RARDE for land activities, Royal Aerospace Establishment (RAE), Admiralty Research Establishment (ARE), and Royal Signals and Radar Establishment (RSRE for electronic technology). Oxlee emphasized that the DRA remains a civil service organization, not privatized, created now for research and development activity. Operations are currently organized in a more commercial mode, with continued consideration for safe-guarding security. The Ministry of Defence continues as the prime agency for international agreements to involve the DRA.

Presentations

J.E. Field, Cavendish Laboratory, University of Cambridge, EMRC chair, introduced the scientific program. Previous EMRC meetings had involved electromagnetic enhancement of detonation in 1987, energetic materials and electrostatic hazard phenomena in 1988, and triaminotrinitrobenzene (TATB) in 1989. John Field and Peter Gray, FRS, at Cambridge, are organizing a Royal Society discussion on Energetic

Materials: New Synthesis Routes, Ignition, Propagation and Stability of Detonation, for November 5 and 6, 1991.

M. Stewart, Synthetic Chemistry Division, RARDE, spoke about the binder chemistry activities among the several other topics of interest to his unit: crystalline energetic materials, energetic plasticizers, nitration technology, and polymerization technology. Whether by (preferred) curing or thermosetting, the future interest is in the binder properties determining the behavior of low-solids-containing composite systems and in the loading and binder versus particle interactions determining the behavior for high solids composites. Binder properties of interest are the glass transition temperature, mechanical extensibility, molecular weight, filler interaction, thermal stability, (isocyanate) cure chemistry, and relation to the composite energetics. Division targets of improved performance, lower vulnerability, ease of processing, and less than current cost were being achieved either by obtaining improved versions of current binders via novel polymerization methods, incorporating pendent energetic units into existing binders, or designing new "idealized polymer" systems. An example of the first strategy, hydroxy-terminated polybutadiene (HTPB) was being produced now with a newly patented organo-lithium "protected hydroxyl functional initiator," (not better defined for proprietary reasons). An example of the second strategy was using N_2O_5 for nitration to achieve ring-opening with high efficiency, thereby improving on epoxidized HTPB. N_2O_5 was being employed to produce nitrate-methyl-3-methyl-oxetane (NIMMO) and glycidyl nitrate (GLYN) materials having relatively high heats of formation. Recent success had been achieved in copolymerizing poly-NIMMO and poly-GLYN. Nitration with N_2O_5 had been used to produce a family of nitratopolybutadienes and other energetic monomers.

G. Bagg, RARDE, followed this presentation with "How to Scaleup for Commercial Production of N_2O_5and Why You Should Want To Do So." The

pure material is a white crystalline solid first reported in Germany in 1911, followed by activity in Poland in the 1940s, and in the U.S. in the 1970s. The material may be produced either from ozone plus N_2O_4 or from nitric acid by electrochemical oxidation of N_2O_4 . Practical difficulties associated with easy degradation of the material, its corrosive nature, and easy leakage because of low surface energy, had contributed to lack of previous utilization. Now Imperial Chemical Industry, via a shared licensing arrangement, had developed their FM21 electrolyzer to allow commercial batch or continuous production. A plant can be supplied under licensing. Corning can supply N_2O_5 in organic solvate under license also. An advantage is that N_2O_5 is totally ionized in HNO_3 , giving reactions at more than an order of magnitude greater rate with minimum byproduct, reduced system volume, and lesser exotherm. The lack of dissociation in dichloromethane provides unique nitrating ability by substitutive or ring-opening actions. Stoichiometric reactions are obtained.

L.B. Chapman, Los Alamos National Laboratory, New Mexico, described work on three different molecules as part of their insensitive high explosives development program: 1,4 dinitroglycoluril (DINGU); "spherical" NQ, nitroquanidine; and, 3-nitro-1,2,4-triazole-5-one (NTO). Although thermally stable, DINGU did not give high enough performance for Department of Energy uses and was found to be more sensitive (even TNT-like) than expected when tested by drop-weight impacting. A spherical growth morphology obtained for NQ crystals, as compared with less effective rod or polygonal crystals, gave better performance than tritonal and was less sensitive. Also, spherical crystals of NTO were less sensitive than cyclotrimethylenetrinitramine (RDX) and to give the high performance predicted. The low burn velocity prevents consideration of any propellant use.

New propellants, in particular, and explosives were the subject of follow-on presentations from French researchers at the Space Division, Le Bouchet Research Centre, Societe Nationale des Poudres et Explosifs (SNPE). B. Finck stated that a research group of 30 persons, including technicians, were involved in increasing impulse densities, detonation pressures, and detonation velocities while maintaining low vulnerability of the materials. A large range of burning rates with RDX and HMX formulations was desirable for ballistic flexibility. Butacene and glycidyl azide polymer (GAP) were binders of interest. Burning rates to 70mm/s were achieved even at high pressure and with low-pressure exponents. Modified HTDP was obtained with an organosilicone ferrocene added by molecular grafting. The product burns faster than catocene, but the ferrocene generally causes increased sensitivity to friction. There is

less problem than with the vapor/condensation sensitivity of ammonium perchlorate (AP). The GAP is compatible with all conventional nitrated plasticizers. Better energetic properties, increased burning rates by 10 to 30 percent with RDX and HMX propellants, smoke-free behavior with no HCl as for AP, and increased stability were touted attributes. There was some question whether temperatures could be achieved in practice to give the favorable burning rates measured in the laboratory. M. Piteau, SNPE laboratory, described a very comprehensive list of dealkylation reactions that were surveyed to possibly produce new energetic binder compounds. Chloroethylchloroformate was used in experiments.

S. Kinlock, Chemical Systems Group, Royal Military College Schriivenham, described work involving Fourier transform infrared (FTIR) and particle-induced, x-ray emission (PIXE) spectroscopy to investigate attempted modification of hydrogen bonding in relatively weaker TATB explosive. Interesting scanning electron micrographs were shown of fractured composite microstructures failed in extensibility tests by decohering of particles or cleavage of the TATB crystals.

Finally, MWG Burt, Atomic Weapons Establishment, Aldermaston, reviewed the application of polymeric binders in plastic-bonded explosive (PBX) formulations relating to weapons technology. Initially, safety considerations were a main factor in replacing cast and pressed cyclotetramethylenetetranitramine/trinitrotoluene (HMX/TNT) by thermoplastic HMX/PBX formulations in the 1960s. Though a lesser problem than with HMX/TNT, density and composition variations in charges continued to be a problem. On cooling of the explosive, cracking caused by different thermal expansions led to an extensibility requirement ≥ 1 percent. Compliant formulations were produced. During the 1970s and 1980s thermosetting, press-cured HMX/PBX technology was obtained from the propellant manufacturers. Service lives of products greater than 40 years were desired leading to a compressive strength requirement ≥ 10 MPa, compressive creep ≤ 0.2 percent, and essentially nil chemical migration rates. Energy equations formulated by M. Kamlet, Naval Surface Warfare Center, Silver Spring, Maryland, and others were used, along with composite-based formulas connecting overall energetics, binder energy, binder density, and volume fractions. A main modern consideration was that online analysis was now recognized to be required in manufacturing technology. The speculative judgement was put forward that the ideal mechanical property for an explosive should be elastic behavior with a low modulus, say 0.5 MPa, while the binder should also be a compliant, totally elastic material.

Developments in the Science and Technology of Composite Materials - Fourth European Conference on Composite Materials

by Michael J. Koczak, the Liaison Scientist for Materials for the Office of Naval Research European Office. Dr. Koczak is on sabbatical leave from Drexel University, Philadelphia, Pennsylvania, where he is a Professor of Materials Engineering.

Introduction

The development of composite materials in Europe was highlighted by the Fourth European Conference on Composite materials in Stuttgart, Federal Republic of Germany (FRG), September 25-28, 1990. The major sessions of the conference included:

- Fabrication
- Fatigue
- Constituents
- Impact and Energy Absorption
- Nondestructive Evaluation
- Interfaces
- Metal Matrix Composites
- Analysis Methods
- Applications
- Ceramic Matrix Composites
- Carbon Carbon Composites
- Properties
- Delamination
- Thermoplastics

The plenary papers included aspects of metal, ceramic, and polymer matrix systems coupled with analysis and applications.

- Production, Properties, and Applications of Metal Matrix Composites by Professor G.A. Chadwick, Hi-Tec Metals, Southampton, U.K.
- Aspects for Recycling - Plastics Engineering Parts, Professor Dr. D.A. Weber, BASF, Ludwigshafen, FRG
- Micromechanics as a Basic Milestone in Fibre Reinforced Polymers and Metals Micromechanics Understanding, J.P. Favre, French Aerospace Research Institute (ONERA), Chatillion, France
- Potential and Design Aspects of Ceramic Matrix Composites, R. Kochendorfer, German Aerospace Establishment (DLR), Stuttgart, FRG
- Glass Reinforced Thermoplastic Matrix Composites (GMT): Technology and Application, Dr. F. Rossi and G. Molina, FIAT, Torino, Italy

Proceedings from the conference can be obtained from:

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655 Avenue of The Americas
New York, NY 10010

Conference Highlights

Recycling of Polymers and Composites. One of the most topical of the plenary papers involved the issues of polymer recycling in the automotive industry. Professor Weber from BASF addressed the need of recycling thermoplastics spurred by the increase of polymers in automobiles. From 1965 to 1995, the amount of polymers will increase from 2 to 13 percent of a car's weight. This projection requires the need for plans on recycling polymers and polymer matrix composites. The concepts for disposal includes three aspects: (1) materials recycling; (2) pyrolysis, hydrolysis, or other approaches for high molecular-weight building blocks; and (3) energy recycling or combustion.

The design of an automobile for polymer recycling can be considered where components can be disassembled and sorted in a short period of time; e.g., 20 minutes. In practice, the automobile can be designed for a recycling operation. The suggested sequence for polymer components can start with the front bumpers and proceed inward. The sequential disassemble within a 20-minute period on a Volkswagen Passat 83 can produce 15.4 kg of polypropylene, 8.7 kg of polyethylene, 5.4 kg of ABS, and lesser amounts of other polymers. Assemblies are being targeted that can be directly reprocessed with little or no scrap; e.g., fuel tanks, bumper, and rocker panels. This design allows direct recycling of these selected components.

The second approach of recycling involves pyrolysis in a fluidized bed in the absence of oxygen into a distillation column to generate pyrolysis oils that can be reclaimed. A hydrolysis approach for polyurethanes, polyesters, and polyamides is being developed to break the polymers into their building blocks. For instance, the polymers can be disassociated at a high temperature in the presence of water.

The third solution is the direct incineration of polymers. However, the impact on the environment has to be assessed particularly with the possibility of dioxin or hydrochloride formation, and the heavy metal contents of the fillers and pigments. BASF is planning a power station based on plastics combustion to demonstrate that the pollution levels can be maintained within permissible levels. The recycling of composites presents a special problem in terms of the high valued-added content of the fibers or rovings. The recycling can utilize a regrinding operation, mild oxidation, or solution. The process can be justified for thermoplastic systems by the high value-added nature of the composite. Each of the recycling processes is very dependent on the cost of petroleum and the local environmental regulations to enforce an industrial mandate to spur recyclable products. In effect, the polymer industry is taking the lead from aluminum companies. The aluminum companies had started a public campaign to promote recycling of aluminum to the betterment of the environment, energy conservation, the health and market share metals industry.

Ceramic Matrix Composites - Potential and Design Aspects. Dr. R. Kochendorfer of DLR gave an excellent presentation of the potential and capability of ceramic matrix composites. In contrast to monolithic ceramics and polymer matrix composites, a comparison of the contrasting material characteristics is depicted in Figure 1. Especially significant is the nearly opposite characteristics and requirements between polymer matrix composites and ceramic matrix composites in

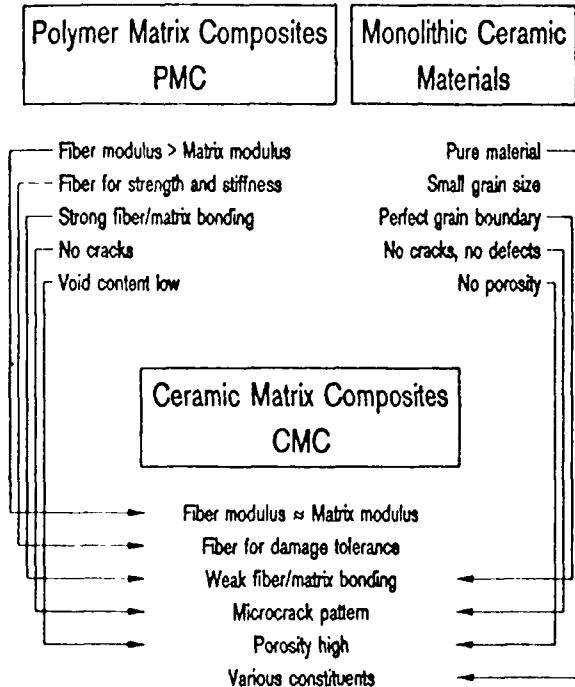


Figure 1. Characterizing material properties for PMC's monolithic ceramic materials and CMC's

terms of microstructure, interface features, and properties. The mechanical properties of carbon/carbon (C/C), carbon/silicon carbide (C/SiC), and silicon carbide/silicon carbide (SiC/SiC) are detailed in Table 1.

Table 1. Mechanical properties of ceramic matrix composites at RT

		2D C/C	3D C/C	2D C/SiC	3D C/SiC	2D SiC/SiC
Manufacturer		Schulz	Aerospaciale	SEP	SEP	SEP
Process		Precursor	CVI	CVI	CVI	CVI
Tensile Strength	MPa	150 - 200	110	350	80	200
Young's Modulus	GPa	70 - 90	31	90	75	230
Elongation at Break	%	0.2 - 0.4		0.9	0.5	0.3
ILSS	MPa	8 - 12	56	35	50	40
Compression Strength	MPa		76	420 - 580	650 - 740	420 - 580
Flexural Strength	MPa	150 - 200		500	300	300
Thermal Expansion	$10^{-4} 1/K$	0.8 - 6.9	0.2	3 - 5	1.7 - 2.3	1.5 - 3
Coefficient of Expansion			0.9	0.8		0.8
Thermal Conductivity	W/mK	15 - 80	4.7 - 22	6.5 - 14	13 - 17.5	10 - 19
Thermal Capacity	J/kgK		840	620	620	620
Porosity	%	5 - 8		10	12	10
Fiber Content	Vol %	55 - 65		45	24	40
Density	g/cm ³	1.55 - 1.65	1.8	2.1	2.3	2.5
Max Temperature	°C	2000	2000	1600 - 1800	1600 - 1800	1300 - 1200

For SiC/SiC and C/SiC, the fatigue behavior is shown in Figure 2, which also depicts the significant modulus degradation. However, the residual strength of both systems is retained at ambient temperatures. The

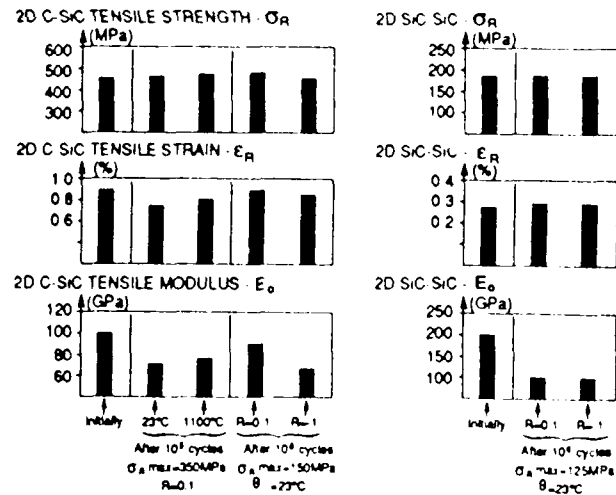


Figure 2. 2D C-SiC and 2D SiC-SiC fatigue behavior [10]

applicability of these 2- and 3-dimensional (3-D) high-temperature systems is seen for large-scale, light-weight, damage-tolerant structures where thin walls and structures can be integrated. The properties of Societe Europeenne de Propulsion (SEP) Cerasep® SiC/SiC composite are detailed in Table 2, and SEP Carbinox C/SiC is shown in Table 3.

Table 2. Average Data: CERASEP®**TECHNICAL SPECIFICATIONS**

Fiber content (by vol.): 40%

Density: 2.5 g. cm^{-3}

		23°C	1400°C
Bending strength	MPa	300	280
Tensile strength	MPa	200	150
Interlaminar shear strength	MPa	40	25
Young modulus	GPa	230	170
Expansion coefficient	1-2 3 10^{-6} K^{-1}	3 2.5	3 2.5
Thermal conductivity	1-2 3 $\text{W m}^{-1} \text{ K}^{-1}$	17 10	17 8
Heat capacity	$\text{J Kg}^{-1} \text{ K}^{-1}$	620	1250

Table 3. Average Data (SEPCARBINOX MIII)**TECHNICAL SPECIFICATIONS**

Fiber Content: 45 percent

Density: 2.1 g/cc

		RT	1500 °C
Bending strength (MPa)		500	550
Tensile strength (MPa)		330	410
Interlaminar shear strength (MPa)		25	40
Young Modulus		100 GPa	100
Expansion coefficient		$4.5 \cdot 10^{-6} / ^\circ\text{K}$	100
Thermal conductivity ($\text{W/m s } ^\circ\text{K}$)	X Y	12 4	18 7
Thermal diffusivity (m^2/s)	X Y	$9 \cdot 10^{-6}$ $3 \cdot 10^{-6}$	$6 \cdot 10^{-6}$ $2 \cdot 10^{-6}$
Heat capacity ($\text{kJ/kg } ^\circ\text{K}$)		250	1500

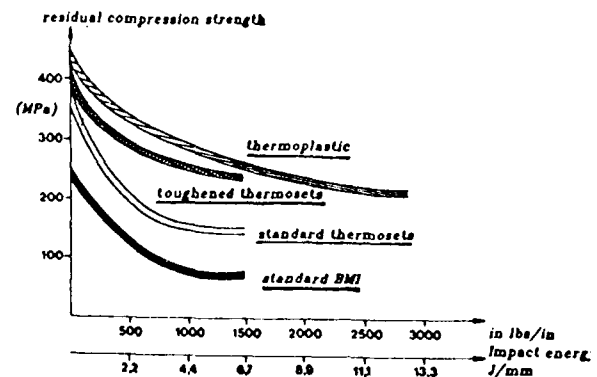
ULTIMATE SPEED OF MORE THAN 500 m/s achieved on spindisks

The above data is corresponding to the state of the art at the printing date but is merely indicative
SEP shall neither be committed by them nor shall it be liable in any way whatsoever

Thermostructural Applications at Societe Europeenne de Propulsion. The development of elevated temperature structures has been led by SEP with the development of C/C, carbon/ceramic, and ceramic/ceramic composite structures. The applications involve propulsion systems and high-temperature thermal structures. The components of the HERMES space vehicle have been examined for leading edges, nose, and vertical stabilizers. In the commercial aircraft

market, a joint SEP-GEC Alstom Company was created; i.e., Carbone Industrie, which specializes in manufacturing C/C brakes.

Approaches to Damage-Tolerant Structures. The increased utilization of graphite composites has raised the issue of the Achilles heel of these reinforced systems, namely, compression response following damage or impact. The compressive strength of graphite fibers is considerably lower than the tensile response, and the impact of damage can further reduce these properties. The four approaches discussed by J. Brandt et al., of Messerschmitt-Bölkow-Blohm (MBB) and the University of Stuttgart, involve 3-D fiber reinforcement, composite design, matrix toughening, and interleaving. A balance must be struck between these approaches, and attention must be directed to the design and processing trade-offs, particularly with regard to modulus and strength degradation. If the level of performance of composite structures is reduced because of the need for damage-tolerant structures, the competition with aluminum structures will become more intense from a cost-effective performance viewpoint. The compression-after-impact response as a function of impact energy of thermoplastics, toughened thermosets, BMIs, and standard thermosets are shown in Figure 3.

**Figure 3. CAI-Performance of Toughened Matrix Systems**

The utilization of 3-D weaving of a toughened epoxy shows the benefit of different weave designs at different impact energies (see Figure 4).

Composite Design. For thin airfoil surfaces consisting of spar and rib components, sandwich construction has been utilized. An alternative approach termed corrugated CFRP substructure (CSS) was considered by Dornier. The requirements of the structure require of skin support shear load efficiency, and adequate torsional and bending stiffness. The advanced monolithic structure permits the integration of the components into one assembly, and fabrication in a single processing step.

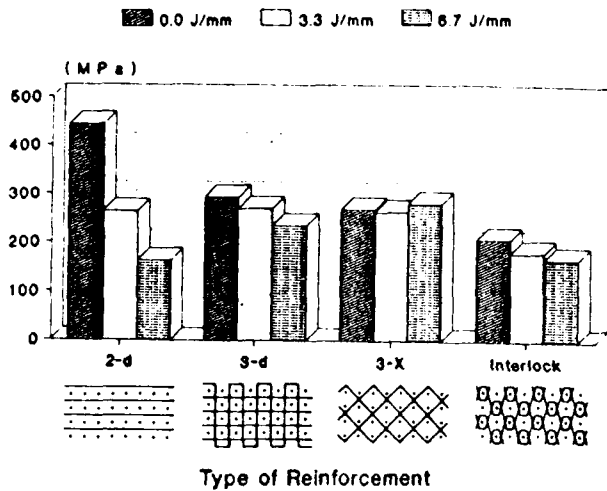


Figure 4. Compression Strength After Impact of Different 3-D Weavings

The design is depicted in Figures 5 and 6, and is compared to the skin-buckling stresses for alternative designs. The future efforts will involve utilization of short-fiber composites or injection molded structures.

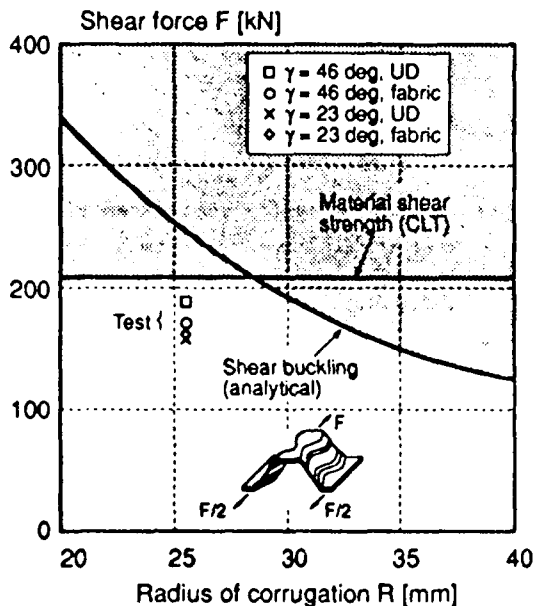


Figure 5. Shear strength test results

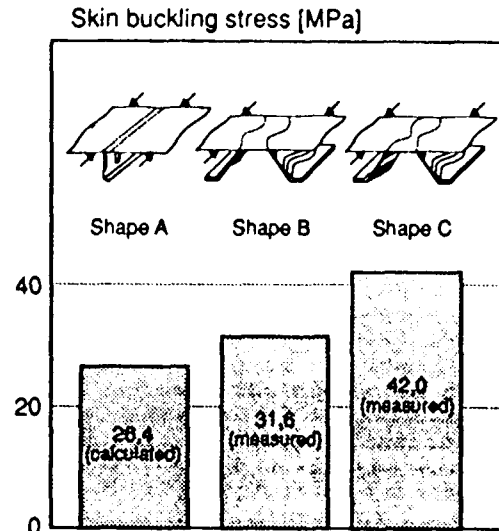


Figure 6. Influence of flange shape on skin buckling stress

In a second presentation, Dornier reviewed the application of thermoplastic composites to commercial products. These include the development of polyether imide (PEI) and polyether ether ketone (PEEK) for structural applications. Certification has been granted for components in an Alpha jet for a horizontal stabilizer-leading edge box and air brake. Performance issues to consider are the erosion and impact response coupled with the creep resistance of these components. A comparison of the production cycles for pressing of thermoplastics and autoclave curing of thermoplastics and epoxy systems demonstrates the benefits of press forming of thermoplastic systems which can be fabricated in 30 minutes while autoclave curing of epoxy systems can exceed 4 hours. The development of thermoplastic composites for aerospace application is motivated by the need for faster processing, improved impact response, unlimited shelf life, improved reparability, and erosion resistance. The drawbacks versus epoxy systems include lower strength at ambient and elevated temperatures and lower creep resistance.

Electron Beam Curing of Composites. Aerospatiale has developed a process involving electron irradiation to cure large-diameter, filament-wound structures. The program's success has spurred the industrialization of the electron beam curing on an industrial level in mid 1991 of filament-wound structure up to 10 m in length and 4 m in diameter. The program's success depends on the contribution of the radiation chemistry which allows for the initiation of the polymerization process by free radical release, chain propagation, and the development of a crosslinked structure. In addition, the resin chemistries are based upon ethylene-unsaturated resin systems; e.g., acrylate epoxides, arylate polyesters, and acrylate urethanes. To couple the fiber (i.e., Graphite IM6) matrix systems, the development of fiber sizings have improved the interfacial shear strength from 40 to 100 MPa with an improvement to the interlaminar shear strength from 25 to 50 MPa.

The utility of electron accelerators for composite curing relies on the variation of electron energies and power density which can be precisely controlled. In addition, the scanning of electron beams over surfaces can be precisely orchestrated by focusing and raster magnets. The production facility involves a high-energy electron accelerator up to 10 Mev and a power level of 20 Kw. The magnetics and positioning mechanism permits the curing of spherical and tubular structures with a diameter up to 4 m and lengths to 10 m with a maximum processing time of 8 hours. The features of the process allow the curing to be controlled spatially as well as in

depth via control of the electron energy and scanning parameters. The combined use of electron beam and x-ray curing has been accomplished with a conversion target that results in x-ray fluorescence. The resulting conversion from electron radiation to x-rays allows greater penetration of the radiation and a greater depth of curing. The benefits associated with the radiation curing involve the ease of electron focusing, shorter curing times with greater depth of penetration (particularly with x-ray conversion), and a lower-temperature cure cycle. Thus, thermal stresses are reduced. The disadvantages involve the capital expense and the special matrix chemistry required with photoinitiators.

Composites Activities in Europe. The major activities of composites research are centered in the aeronautic, space and automobile, and transport sectors. Additional areas of interest include petrochemical, biomedical, general manufacturing, sports, leisure, building, furniture-rotating machinery, and marine. A list of the European research centers in composite materials was edited by A.R. Bunsell and A. Kelly and published by Butterworths Press. The publication provides a listing of personnel, research establishments, research areas; e.g., matrix, fibers, properties, processing, design, and analysis and applications. A second compendium is European Centres of Development on Advanced Composite Materials-Directory of European Activities published by Metra Martech, 1 Queen Annes Gate, London, SW1H 9BT, U.K.

Appendix

BRITE/EURAM Composites Programs-Polymer Matrix Composites. The European Community has developed a major research effort directed at several materials areas. Of particular interest to the composites community are the Basic Research in Industrial Technologies for Europe/European Research on Advanced Materials (BRITE/EURAM) efforts that have several joint research programs in metal matrix composites, composite processing, ceramic composites, and polymer matrix composites. The following is a summary of the research programs in polymer matrix composites with the partners and countries indicated.

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Polymer Matrix Composites

Title	Partner	Country
New reinforced thermoplastic materials	*Eniricerche Battenfeld Extrusion Tech IKV POLYDATA, Ltd..	I D D IRL
Development of alternative thermoplastic material forms for use of high-performance thermoplastic composites	*Messerschmidt-Bölkow-Blohm (MBB), GMBH Centre National de la Recherche Scientifique, Mulhouse	D F
High-performance reinforced thermoplastics for aerospace structural applications processed by injection moulding	*AEROSPATIALE British Aerospace ARMINES IKT Stuttgart MBB	F UK F D D
Mechanical and physical properties for new products made of polymers-the sulcated spring	*DISC Computer Svcs, Ltd. Spring Research & Manufacturers Association Mica and Micanite, Ltd. Ressorts Martin Prunier	UK UK IRL F
Development of CFRC materials with partially reduced carbon fibre content for use in car brake systems	*Daimler-Benz AG Schunk Kohlenstofftechnik GMBH, Geissen Institut Für Chemische Techn. Uni, Karlsruhe Carbone Industrie, Villeurbanne Sigri GMBH, Meitingen	D D D F D
Development and characterization of high-temperature performance semicrystalline thermo-plastics matrix polymers for carbon fibre composites	*ICI PLC Université Catholique De Louvain	UK B
Optimizing structural fibre composites by hybridization	*Loughborough University of Technology PERA Institute of Polymer Technology & Materials Engineering Cetim	UK UK F

Title	Partner	Country
The role of the fibre-matrix interface on the mechanical behavior and damage development in carbon-fibre-reinforced plastic composites	*University of Surrey Courtaulds Research Ltd., Coventry Katholieke Universiteit, Leuven Centro de Quimica Fisica Molecular Deutsche Forschungsanstalt für Luft-Und Raumfahrt (DLR), Köln-Porz	UK UK B P D
Advanced composite materials based on carbon fibres modified by plasma/or electropolymerization	*Facultés Universitaires Notre Dame de la Paix University of Bath, Dept. of Material Sciences	B UK
Development of thermostable new high-performance composites based on bismaleimide modified siloxanes matrix and continuous carbon fibres	*Rhône-Poulenc Centre De Recherches des Carrieres UNIREC AKZO Polymer and Fiber (Enka) University of Athens	F F D GR
Development of continuous carbon-fibre-reinforced thermoplastics and their processing for composite components	*Dornier Luftfahrt GMBH Brochier SA DLR Hellenic Aerospace Ind., Ltd. University of Patras	D F D GR GR
Lightweight mirrors made of carbon-fibre compound for optical application	*Ruhr Universität MAN Technologie, München Space Research Laboratory, Groningen	D D NL
Lightweight reflectors of carbon-fibre-reinforced plastic	*Friedr. Krupp GMBH Oldelft University of Patras	D NL GR
Development of high-temperature polyimide composite systems	*BP International Ltd. ERA Technology, Ltd. MTU GMBH Dornier GMBH	UK UK D D
Fibre-reinforced plastic composite engine	*Ford-Werke AG DSM Ford Motor Co., Ltd. Galvanoform GMBH GKN Technology National Engineering Lab. University of Nottingham Vetrotex Saint-Gobain	D NL UK D UK UK UK F
Development of improved damage-tolerant carbon fibre-matrix composites	*Aerospatiale AMD-BA BROCHIER SA CASA ENKA-AG MBB University of Patras	F F F E D D GR

Title	Partner	Country
Development, characterization, and utilization of novel modified amorphous polyaromatics for use as composite matrices	*ICI PLC Dornier GMBH GASA Université Catholique De Louvain University of Birmingham ETH Zürich	UK D E B UK CH
Improving durability and performance of thermoplastic-based composites using novel adhesion-promoting polymer interfaces	*Ecole Des Mines Centre Des Materiaux University of Aston Institut Francais du Pétrol	F UK F
Lightweight hybrid composites with improved damage tolerance based on high modulus polyethylene and glass fibres	*The University of Leeds Université des Sciences et Techniques de Lille	UK F
Simulation, detection, and repair of defects in polymeric composite materials	*Agusta Spa MBB Westland Helicopters, Ltd. CIRA RISØ	I D UK I DK
Numerical and experimental techniques for composite material, structural design, and validation in advanced industrial applications	*Thompson Sintra ASM Ansaldo Spa SIMULOG ARS Spa	F I F I
Design methodology for the improvement of damage tolerance within composite structures	*British Aerospace (Military A/C) Ltd. MBB SAAB Dornier Fokker Imperial College N.L.R. University of Leuven	UK D SF D NL UK NL B
Composite material for marine structures and components	*Cetena Spa Bureau Veritas IFREMER Filncantieri CNI MIKI Technical University of Lisbon E.N.S.M. CETIM Vetroresina R.I.N.A.	I F F I I P F F I I
Reaction injection moulding (RIM) and energy conservation in the processing of fibre-reinforced thermoplastic composites	*University of Liverpool Universita degli Studi di Napoli University of Patras Technische Universität, Hamburg	UK I GR D

Title	Partner	Country
Precompression of individual layers in multilayer CFRP composites to increase the threshold for interfibre/matrix cracking	*Urenco Limited Rise National Laboratory MAN Technologie AG	UK DK D
Development of techniques for processing "large" organic sheets, thermoplastic prepregs, ribbons, and foils	*Dornier Luftfahrt GMBH Akzo, Fibres and Polymer Div. Enka AG Wuppertal Petrochemie Danubia GMBH, Linz Agusta Spa, Milano Hellenic Aerospace Industry Ltd., Athens	D D A I GR
Automatic laying of unidirectional C.F.C. on double-contoured surfaces	*Aeritalia Saipa Jobs Spa BASF	I I D
Filament winding of thermoplastic materials	*Per Udsen Co. Technologies A/S Dornier ICI IKV	DK D UK D
Durability of continuous fibre-reinforced thermoplastic composites with emphasis on the interface behavior and the method of fabrication	*NV KEMA Institut National de Recherche Chimique Appliquée Centre des Matériaux Pierre-Marie Fourt Armines National Engineering Lab. (NEL) Integrated Aerospace Science Corporation (INASCO) Universidad De Valladolid	NL F F UK GR E
Development of techniques for polymeric diaphragm forming of continuous fibre-reinforced thermoplastics	*Dornier Luftfahrt GMBH CASA Petrochemie Danubia GMBH ETH Zürich University College Galway	D E A CH IRL
Injection and blow moulding of fibre-reinforced thermosets and thermoplastics with optimized fibre length and mechanical properties - "Inblofil"	*Friedr. Drupp GMBH NV DSM DSM Research BV	D NL NL
Development of design and processing techniques for overinjection of thermoplastic composites	*MCS International CRIF DLR University College Galway Armines FN	IRL B D IRL F B

* Indicates Prime Partner

Country Codes

A	Austria	IRL	Ireland
B	Belgium	L	Luxembourg
CH	Switzerland	NL	The Netherlands
D	Federal Republic of Germany	NO	Norway
P	Portugal	DK	Denmark
S	Sweden	E	Spain
SF	Finland	F	France
UK	United Kingdom	GR	Greece
		I	Italy

Further information of the BRITE/EURAM programs can be obtained at no cost from the European Communities Offices in:

Washington

2100 M St., NW (Suite 707),
Washington, D.C. 20037
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NEWS, NOTES, AND ABSTRACTS

Fourth International Colloquium on Graphs and Combinatorics

by Edward R. Scheinerman, Professor, Department of Mathematical Sciences, The Johns Hopkins University, Baltimore, Maryland

Introduction

The Fourth International Colloquium on Graphs and Combinatorics was held at the University of Marseille-Luminy in Marseille, France, during the week of July 9-13, 1990. The conference featured over 100 invited and contributed lectures. Therefore, it is impossible to give here a detailed description of all the activity at the conference. Rather, I describe the general scope of the conference and focus on a particularly interesting presentation on random subgraphs of the hypercube.

Graphs and Combinatorics

Graph Theory and Combinatorics are branches of mathematics concerned with the study of discrete, finite structures. In addition to *pure* problems, research in these areas have yielded applications to radio frequency assignment, archaeological seriation, design of parallel computer architecture, experiment design, vehicle routing, facility location, computer processor and memory allocation.

Random Subgraphs of the Hypercube

A hypercube is a mathematical object that arises in many disciplines. An ordinary cube has 8 corners (also called vertices) that can be labeled by the binary numbers 000 through 111 so that neighboring corners differ in exactly one binary digit (see Figure 1).

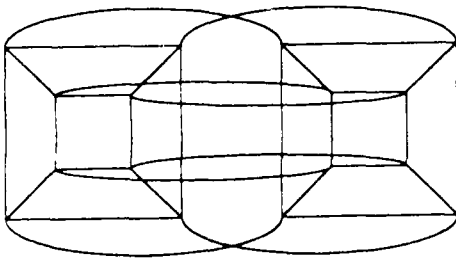


Figure 1. A 3-cube

A hypercube is a generalization of an ordinary cube. Given a positive integer k , a k -cube has 2^k vertices indexed by the k -digit binary numbers 000...0 through 111...1; two vertices are joined by an edge when their binary labels differ in exactly one bit. Figure 2 shows a schematic representation of a 4-cube.

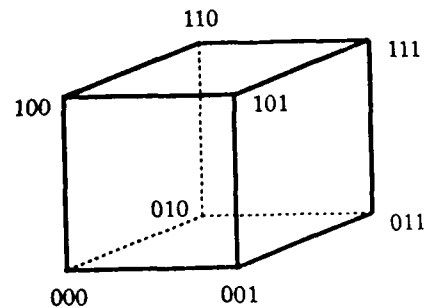


Figure 2. A 4-cube

Hypercubes have been extensively studied especially as architectures for parallel computers. Each vertex of the hypercube is a processing unit; edges between vertices represent direct communications links. Processors that are not directly connected to each other must have their communications routed through intermediate processors.

Professor Béla Bollobás, University of Cambridge, U.K., presented a lecture on his research on random subgraphs of the hypercube. Each edge of the hypercube is present at random: for each edge of the k -cube, one flips a coin. With probability p , the edge is present in the graph; but with probability $1-p$, the edge is absent. In a parallel computer, this corresponds to the fact that communication links between processors may be faulty. For *large* values of p , the overall graph is very likely to be connected; i.e., every processor can communicate with every other processor, perhaps through intermediate nodes. For *small* values of p , the overall structure is likely to be disconnected; i.e., there will be pairs of processors unable to communicate. Between *large* and *small* is a well-defined threshold at which the structure becomes connected. Professor Bollobás studied the structure of the random hypercube when p is just below this threshold. In particular, he discussed the size of the largest and second largest connected piece of the random structure. Also, he compared his results to classical results in the study of random graphs initiated by P. Erdős and A. Rényi some 30 years ago.

The Bernoulli Society for Mathematical Statistics and Probability

by Toke Jayachandran, Professor of Mathematics, Naval Postgraduate School, Monterey, California.

Introduction

On August 13-18, 1990, in Uppsala, Sweden, the Second World Congress of the Bernoulli Society was held jointly with the 53rd Annual Meeting of the Institute of Mathematical Statistics. The meeting attracted more than 800 international participants (100 - U.S., 50 - U.S.S.R.).

The highlight of the meeting was a set of nine special invited lectures presented by well-known probabilists/statisticians. In addition, the program included several contributed paper sessions and 36 invited sessions. Topics included graphical structures/expert systems, inverse problems, percolation, image analysis, population dynamics, environmental monitoring, stochastic geometry, chaos, mathematical genetics, statistical aspects of AIDS-modeling, and meta-analysis in medical statistics.

Report Summaries

Wald Memorial Lecture: Some Aspects of Parametric Statistical Inference, Sir David Cox, Nuffield College, Oxford. Professor Cox presented three lectures on the choice between different procedures, all equivalent to the first order asymptotic theory, improvements in distributional approximations, and the modifications to maximum likelihood procedures needed to deal with difficulties related to the presence of many nuisance parameters. In addition to describing the state of the art, Cox presented several new results obtained by him and his collaborators.

Neyman Lecture: Neural Nets and Implicit Inference, Peter Whittle, University of Cambridge, U.K. The theme of this lecture was that neural networks operate by a continuous process of hypothesis testing, distributed in time and space. Professor Whittle demonstrated a stochastic version of the Hopfield Net (the antiphon) as a model for achieving reliable memory despite unreliable operation of its components, and derived exact expressions for the memory capacity of the antiphon.

Cramer Lecture: Likelihood Based Inference for Cointegration of Nonstationary Time Series, Soren Johansen, Copenhagen University, Denmark. The notion of a cointegrating relation; i.e., a stationary linear combination of nonstationary multivariate time series makes it possible to apply mathematical-statistical methods to study nonstationary time series of the random walk type. Johansen presented a methodology based on vector autoregressive models with Gaussian errors to achieve cointegration.

Special Invited Lecture: From Optimal Skipping to Random Time Change on Recent Advances in Exchangeability Theory, Olav Kallenberg, Auburn University, Alabama. Professor Kallenberg discussed the notions of optimal skipping, strong stationarity, and strong homogeneity and indicated how the modern theory of exchangeability unifies all these concepts. He then showed that exchangeable processes are essentially semimartingales whose local characteristics are absolutely continuous and admit densities that are themselves martingales. He then went on to demonstrate that the theory of exchangeability can be used to show that the strong Markov property of a process is equivalent to a much weaker strong homogeneity property.

Bernoulli Lecture: Finite Dimensional Randomness, Yakov Sinai, Landau Institute of Theoretical Physics, Moscow. Professor Sinai discussed the theory of deterministic chaos and in particular the Lorenz system of differential equations. He then developed a theory of finite-dimensional randomness. He showed how this theory may be applied to study chaotic systems such as geodesic flow on manifolds of negative curvature, dispersing billiard balls, Lorenz systems, and Axiom A systems.

IMS Special Invited Paper: The Biology of Random Permutations - The Poisson Dirichlet and the Gem Distributions in Applied Probability, Peter J. Donnelly, Queen Mary and Westfield College, London, and Simon Tavaré, University of Southern California, Los Angeles. The main thrust of the paper is the use of the Poisson-Dirichlet and the GEM distributions on the infinite simplex to study the asymptotics of a wide range of problems in applied probability such as random permutations, record values, neural models in population genetics, random mappings, self-regulating filing systems and probabilistic number theory. An embedding in the well-known birth-and-death process provides a convenient tool for studying this asymptotic behavior.

IMS Special Invited Paper: Computer Algebra and Stochastic Calculus, Wilfrid S. Kendall, University of Warwick, U.K. The theme of Professor Kendall's lecture is the use of the contemporary computer algebra packages such as REDUCE, MATHEMATICA, and MACSYMA, to perform symbolic calculations that closely reflect the content of the underlying theory. He demonstrated the use of REDUCE to implement the "Ito multiplication rule" and showed how the resulting symbolic Ito calculus may be used to study semimartingales, stochastic differentials, and the other apparatus of stochastic calculus. He also described the use of REDUCE in an investigation of shape diffusions.

Special Invited Lecture: Kolmogorov as I Remember Him, D.G. Kendall, Cambridge University.

Concluding Remarks

On August 17, at a banquet in the famous Uppsala Castle, the Institute of Mathematical Statistics presented its newly elected fellows. The next Congress of the Bernoulli Society will be held in the U.S. in 1993.

Commercialization of the Programming Environment for SIGNAL

by Robert D. Ryan

The Centre National d'Etudes des Télécommunications (CNET) and the Institut National de Recherche en Informatique et en Automatique (INRIA) have recently made an agreement with TNI - Industries (PMI de Brest, Finistère) giving them the rights to further develop and commercialize a programming environment for the language SIGNAL.

SIGNAL is a real-time, synchronous language that is particularly well suited for the description of real-time algorithms for signal processing. The language has been under development for several years at INRIA - Rennes, where it has been the focus of activity in the project entitled *Environnement de Programmation pour Applications Temps Réel (EP-ATR)*. From the beginning, the objective has been to develop a real-time, parallel language tailored for signal processing. The people most closely associated with the work recently are Paul Le Guernic, Albert Benveniste, Patricia Bournai, Thierry Goutier, Michel Le Borgne, and Viviane Kerseaven. I note that Benveniste also heads a large INRIA project called *Automatique et signal*, which covers many aspects of signal processing.

SIGNAL is related to the synchronous languages ESTEREL and LUSTRE. ESTEREL is an imperative style language, while SIGNAL and LUSTRE are data flow languages. With these languages it is possible to express the timing constraints of an application rigorously and independently of any target machine. The synchronous paradigm and the ability to formulate in advance all of the temporal constraints offer advantages for code generation and for modifying programs. One can tailor timing and communications to the application without worrying about the implementation. The SIGNAL environment allows one to visualize the action of the program on a signal in "slow motion" and be assured that the action at slow speed is the same as it is in real time.

The software environment which is the object of this license is written in C, but it was translated from source programs in Smalltalk80. The environment is portable and easily adaptable to the standard windows environments (Xwindow, SUN-View). A special effort has been made on the man-machine interface; the user makes reference to a graphic form of the SIGNAL

program at different phases of the work--from specification to execution.

TNI-Industries have specialized in interactive applications since 1985, and they have been pioneers in the development of methodologies based on object-oriented programming. Their participation in the elaboration of the SIGNAL environment gives them a strong position in the field of signal processing tools.

The software environment that is being transferred to TNI-Industries is a result of a cooperative effort between CNET and INRIA which started in 1985. The objective of this effort is to produce general tools for the development of real-time signal processing systems.

Marine Microbial Ecological Methodology

by Keith E. Cooksey

In October 1990 in Damp, Federal Republic of Germany (FRG), an informal workshop with the above title was held in conjunction with the Fourth European Marine Microbiological Symposium. There was no formal agenda and the discussion became somewhat passionate at times in spite of the efforts of the convener and moderator, Dr. T. E. Cappenberg, Limnological Institute, Nieuwersluis, the Netherlands.

The first topic discussed was sampling; this provoked little interaction. Most people seem to be happy with the current methods, but it was suggested that pore water was better removed from cores by syringes than by the use of a squeezer. The Niskin butterfly sampler was believed to leak on very deep sample casts, but then I do not believe Shale Niskin ever expected it to be used at 2000m. Dr. G. Rheinheimer, Kiel, FRG, said that they now had a modified device which worked better than previously described versions. An examination of the ratio between a chemical and a microbiological parameter can be used to detect contamination. Small-scale sample variation still seems to be a serious problem for sediment microbiologists and they have no new ways of dealing with it.

The discussion on patchiness lead to a consideration of the methods used to describe the microbiological sample. The point was made that since the methods used are not particularly reliable, how could one even detect patchiness in a series of sediment core samples (or even water column samples, for that matter). Variation could be no more than lack of reproducibility of the methods. The simplest method to examine microbial populations, it was agreed, is by fluorescence microscopy. The fluorescent stain of choice, however, produced considerable disagreement.

Dr. L. Meyer-Reil, Kiel, FRG, defended acridine orange, Dr. N. P. Revsbech, Aarhus, Denmark--DAPI, and I--Hoechst 33258. No one believes the orange/green colors obtained with acridine orange have any

physiological significance--or at least no one contradicted Dr. Meyer-Reil when he pronounced that such was the case. Many of the problems associated with low fluorescence yield of U.V. excited stains are associated with poor shortwave transmission of glass objective lenses. A vigorous vote for DAPI over acridine orange was made by Dr. Lucila Acosta, Messina, Italy. She considered DAPI easier to use, had a bright color, and the fluorescence decayed slower than other stains.

There followed a short discussion concerning the desirability of Kingdom-specific fluorescent probes, although no one admitted to using or working on them. However, earlier in the day, Dr. M. Hofle, Plon, FRG, had given a review of the use of nucleic acid specific probes in microbial ecology. Some of the work he described was supported by the Office of Naval Research.

The rest of the evening was devoted to the measurement of activity of microorganisms and the factors to be used to convert ^3H thymidine uptake rates into numbers of bacteria. As one may suspect, there was no consensus for the conversion factor with figures of between 1 and 200×10^{18} cells/mole being quoted. Most people were in favor of a figure between 0.5 and 2.0×10^{18} cells/mole. Much of the problem appears to surround the ambient level of thymidine and thus the actual specific activity of the ^3H -thymidine in the incubation. This problem was greatest when sediment samples were investigated. Some people suggested that the method was only useful in planktonic, aerobic situations. I suggested that a preliminary experiment with ^{14}C -thymidine that resulted in the detection of $^{14}\text{CO}_2$, would preclude the use of the ^3H -thymidine method entirely. The suggestion was not popular.

Also at issue was the level of specific activity and concentration of the added substrate, the incubation time, and the difference between marine and freshwater environments. It was agreed that purification of DNA before counting lead to better results than merely counting cells washed in place on filter membranes. At least problems of isotope dilution--the need to work at saturating concentrations of substrate and the instability of very high specific activity thymidine--were recognized by this group. However, it seems unlikely to me that the proposal to use high specific activity ^{14}C -leucine in place of ^3H -thymidine or ^3H -leucine is a solution to the radiochemical instability problem.

Many of the difficulties related to measuring meaningful leucine incorporation rates as a means to estimate cell numbers and activity are the same as those for thymidine; e.g., lack of knowledge of environmental concentrations, conversion factors. One good idea presented was that if dual-label compounds were used and counting ^{14}C and ^3H gave similar rates, then at least one knew that the molecules were probably being incorporated intact. One problem in measuring

^{14}C -leucine incorporation as a measure of protein synthesis that was not discussed but I will mention it here. Protein turnover in microorganisms is a function of growth rate. Starving cells have a much higher protein turnover rate than cells growing with a sufficiency of nutrient. This is related to the stringent or alarmone response. Further, it was proposed that not all environmental leucine is "available" for microbial use. I was unable to gather whether this is because of adsorption phenomena or other reasons.

This European workshop was attended by all the European ecologists I know so it is likely that the problems aired there are universal. Since world climate models involve biogeochemical cycling and the marine microbial food web, I think it is essential that those who roam the oceans collecting data for such models could at least agree on the techniques to be used.

The proceedings of the workshop will not be published.

The Fifth European Congress on Biotechnology

by Keith E. Cooksey

Introduction

The Fifth European Congress on Biotechnology (ECB5) was held on July 8-13, 1990, in Lynby at the Technical University in Denmark, and was organized by a professional conference bureau. I suppose with the size of modern conferences, it is perhaps too much to ask local academics to organize them; but certainly, a good deal is lost when profit is a driving force. I heard several complaints from exhibitors and delegates at the meeting relative to fees and just what one obtained for the cost. I hope collegiality is not going the way of the dodo! The proceedings of the meeting will be published (ISBN 87-16-10617-2).

Microbial Corrosion

No discussion took place concerning the degree of involvement of microbes--it was assumed that microorganisms play a crucial part in the process. Apparently, not everyone agrees with this concept, especially those working at the shipyard level. In his opening talk, Dr. Tiller, National Corrosion Service, Teddington, U.K., was quite definite and he spoke of "microbially-induced corrosion." This was entirely reasonable, since Dr. Tiller is chairman of the European Federation of Corrosion Working Party on Microbial Corrosion. During his presentation, Dr. Tiller reviewed the corrosion problem, and the economic losses involved. The figures he gave were not new, but he placed them in a new light. In the U.K. losses caused by corrosion exceed 3 percent of the gross national product! He also discussed an aspect of corrosion not usually appreciated

by academic microbiologists (i.e., how do you tell what is likely to be happening on the surface of a piece of corroded metal just by looking at it?). Practitioners of engineering at the truly basic level (such as plumbers and shipyard pipefitters) should be able to recognize telltale signs of microbial involvement in metal degradation without resort to an industrial microbiology laboratory. Thus, Dr. Tiller described the gross anatomy of corrosion pits in a variety of metals and why, for example one should not bury stainless steel pipes in anaerobic sulfate-containing peat! He also described a comparatively new problem in the U.K. regarding soft water and the corrosion of copper domestic plumbing. There is now considerable interest in this area of study.

In another paper Kate Nielsen, Engineering Academy of Denmark, Lyngby, pointed out that corrosion is a serious problem in aerated water systems, where sulfate-reducing bacteria could not be detected. From her talk, it was not obvious whether samples were taken from the water or from the wall of the pipes. However, Dr. Nielsen recognized that biofilm formation on pipes causes complications.

Hans Battig, an engineer with Georg Fischer Piping Systems, Ltd., Schaffhausen, Switzerland, explained the benefits of using polyvinylidene fluoride (PVDF) piping in place of stainless steel, especially for water used in the semiconductor industry. Evidently, PVDF pipework is no more expensive than stainless steel, and can be made much smoother, especially in the bore. Surface irregularities of only $0.2\mu\text{m}$ can be obtained, and the polymer is not toxic. He reported that since the material is hydrophobic, only minimal biofouling occurs (a statement that could not be defended under questioning from the audience). In our experience, hydrophobic plastics foul quicker than surfaces that are hydrophilic, although the former are easier to clean. Relative to this is the fact that wholesale sloughing of a biofilm, even one of comparatively small thickness, would cause severe problems in ultra pure water systems. The PDVF piping can be sterilized by chemical treatments.

Liv Fiksdal and her colleagues from the Norwegian Institute of Technology, Trondheim, gave a talk devoted entirely to chemical sterilization of process pipes (stainless steel in this case). I was very interested in her demonstration that colony-forming units of microorganisms (CFU) in biomass on the pipes correlated well with 4-methyl umbelliferyl heptanoate hydrolase (MUH'ase) activity. Liberation of umbelliferones can be detected, with high sensitivity, by fluorescence measurements. Researchers at the Norwegian Institute of Technology used adenosine triphosphate and electron transport measurements to quantify cellular activity, but MUH'ase proved to correlate better with CFU determination. With these methods, they were able to show that continuous

chlorination controlled biofilm formation less well than did a daily 30-minute pulse. Notably, biofilm coverage of the pipes was quite variable, ranging from 0.2-50 percent in the same pipe. This must have presented a problem while collecting representative samples of attached biomass!

The last paper, presented by Victoria Scotto, Institute for Marine Corrosion in Genoa, Italy, discussed the production of extracellular polymeric substances by bacteria and correlated this with their potential to cause corrosion. The relationship is not linear, however, unless a semilogarithmic plot is used. In contrast to others in the field, this group believes that they have ruled out the importance of light-driven biochemical reactions in microbially-enhanced corrosion. The symposia chair remarked that, in some quarters, electrochemical studies on test coupons were not considered meaningful in predicting real-world corrosion rates. That comment led to an exchange from the audience. One member of the conference stated that, in spite of the almost "blasphemous" nature of this remark, he believed that it contained an element of truth. Gross electrochemistry will not give an assessment of what is happening in pits. At the whole coupon level of resolution, all that is seen is the integration of all electrochemical reactions. What is needed is resolution at the tens of micrometer level; i.e., the size of a bacterial microcolony.

Marine Biotechnology

A marine biotechnology workshop contributed little on biofouling, but of interest was information on compounds being researched by the Marine Biotechnology Center of the Danish Ministry of Fisheries. This group has a working relationship with Hempel Paints, Denmark. Various compounds were extracted from marine invertebrate organisms, and are terpenoid in nature or sulfur-containing; e.g., (2-hydroxyethyl) dimethyl sulfoxonium ion. Some are said to perform as effectively as tributyl tin oxide in experimental coatings. Their mode of action was suggested to be as behavioral modifiers, rather than toxins.

Mathematical Methods in Image Analysis

by Stuart Geman, Professor of Mathematics, Division of Applied Mathematics, Brown University, Providence, Rhode Island.

Introduction

In July 1990, I attended and participated in two workshops on the general topic of mathematical methods in image analysis. The workshops were at the Instituto per le Applicazioni del Calcolo in Rome, Italy, and the Mathematics Institute in Oberwolfach, Germany, respectively. Both programs were more or less spontaneous with no schedule of talks or events to show.

My interest was in the use of hidden Markov models for recognition and other image processing tasks. I

discussed and studied several practical and theoretical issues associated with these image-processing tools.

Hidden Markov Models

The relation between hidden Markov models and Gibbs distributions was discussed. Also, the dynamic programming solution to various calculations associated with Gibbs distributions was laid out, including the computation of most likely states, expected values, and partition functions. The computational feasibility of dynamic programming depends on the graph associated with the Gibbs distribution. In general, one-dimensional models of low order (nearest or near-neighbor models) lend themselves to dynamic programming analysis, although some compromises; e.g., pruned search, may be necessary. Various recognition tasks can be cast as the solution to optimization problems involving one dimensional Gibbs distributions, and thereby lend themselves to dynamic programming algorithms.

Following earlier work by Ulf Grenander, my colleague, Kevin Manbeck, and I have developed R^2 -valued 2nd-order Markov models for the shapes of coronary arteries in angiograms and for handwritten numerals. These are examples of a general and well-known approach to shape modeling through deformable templates. In Grenander's approach, the modeling step results in a collection of distributions—one for each generic shape. For example, there may be three models corresponding to the three major coronary arteries. Conditional data models are developed that describe likely grey-level presentations of the shapes given a particular realization from a shape ensemble. A posterior distribution is derived that is approximately second-order Markov. Dynamic programming is used to calculate the probability associated with the best fit of each model to the image. Good fits are candidate classifications, and preliminary experiments have been encouraging.

Several refinements were discussed and studied in some depth. For example, a coarse-to-fine search strategy was developed, and extensions to inhomogeneous deforming distributions, which would better accommodate an object's natural degrees of freedom, were studied.

A common ingredient in our work on image processing and analysis has been using Markov processes, of the usual one-dimensional variety as well as more general Markov processes, including two- (2-D) and three-dimensional (3-D) random fields. These processes have been used to model structure and variability of image attributes and objects. Thus, we have used 2-D Markov random fields as models for grey-level distributions and boundary placement for modeling textures, and for modeling isotope concentration maps in single photon emission computed tomography. More

recently, they have been used for 1-, 2- and 3-D random fields for modeling shapes in reconstruction and recognition experiments. In these applications, as well as in the application of Markov models to speech recognition, what are actually observed are functions (sometimes random) of the Markov process. The observables are thereby hidden Markov. The resulting observation process itself is typically not Markov. In fact, it is likely to have a very complex dependency structure. Indeed, this is behind the utility of hidden Markov models.

The model is built from local pieces (a local Markov process, or random field, and a local observation equation), but can account for highly complex and nonlocal structures in the observations. The question arises as to how general is the class of hidden Markov models.

To make this precise, consider, for example, the class of first order hidden Markov models in one dimension. Let $\{x_t\}_{t=1}^{\infty}$ be a stationary first order Markov process with finite state space Ω_x . Let $f: \Omega_x \rightarrow \Omega_y$ where Ω_y is also finite, and typically $|\Omega_y| < |\Omega_x|$. Then $y_t \doteq f(x_t)$ is a hidden Markov model. How rich is the class of such processes? Apparently very rich, as indicated by the following relatively easy result: **Theorem.** Let $\{y_t\}_{t=-\infty}^{\infty}$ be a stationary process with finite state space Ω_y . There exists a sequence of finite-state stationary hidden Markov models $\{x_t^N, \Omega_x^N, f^N(\cdot)\}$, such that the processes

$$y_t^N \doteq f^N(x_t^N)$$

converge weakly to $\{y_t\}_{t=-\infty}^{\infty}$.

The analogous result in higher dimensions, involving nearest neighbor Markov random fields in place of first order Markov processes, appears to be much more difficult, though there are good heuristic arguments in its support. Approximation theorems such as these suggest the availability of more or less universal representations. In proving the above theorem, one takes $|\Omega_x^N| \rightarrow \infty$, which suggests looking at the class of infinite (say continuum) state space hidden Markov models. Using the Gibbs-Markov equivalence, this amounts to studying hidden Gibbs processes of the form:

$$\pi(\{x_t\}) = \frac{1}{Z} \exp\left\{-\sum_{\langle s,t \rangle} V(x_s, x_t)\right\}, \quad y_t = f(x_t)$$

where π is a probability distribution (of the Gibbs form), $V: [0, 1]^2 \rightarrow R^1$, $x_t \in [0, 1]$, Z is a normalizing constant, $\langle s, t \rangle$, are nearest neighbors on the square lattice system in the appropriate dimension, and $f: [0, 1] \rightarrow \Omega_y$, which is finite.

The evidence is that this covers nearly all stationary finite state random fields in a given dimension. (The use of Gibbs distributions clearly imposes some limitations in terms of the positivity of marginal probabilities.) If such representations can be established, then it would be interesting to explore the estimation of the functions V and f based upon observations of the process $\{y_t\}$. This estimation may be possible, for example, by the method of sieves, or by some other nonparametric technique. An intriguing application would be to the modeling and rendering of textures for computer graphics and simulations.

Support for French Mathematics at the Centre National De La Recherche Scientifique

by Charles T. Owens, National Science Foundation, Europe Office, Paris

Introduction

This report stems primarily from conversations with Centre National De La Recherche Scientifique (CNRS) personnel, especially M. Jean Pierre Ferrier. M. Ferrier is Directeur Adjoint in the section of CNRS devoted to mathematics and basic physics, and he is in charge of the mathematics programs. Except as otherwise indicated, the opinions expressed are M. Ferrier's as I understood them.

Problem

In 1987, French mathematics undertook a self examination 3 years after a similar introspective look in the U.S. The U.S. examination yielded the "David Report" with a colloquium "Mathematics to Come" (Mathematique a Venir). This meeting, held at the École Polytechnique, came up with two principle conclusions which have been addressed by CNRS in the years since:

- Mathematics is no longer a "light" science but a substantial one that requires more substantial support from CNRS
- French mathematics needs more full-time researchers, rather than teacher/researchers.

Solutions

The consequences of these conclusions have fallen primarily on CNRS. The Mathematics/Basic Physics Section of CNRS has created the post of Assistant Director now held by M. Ferrier. Between 1987 and 1990, the support for mathematics in CNRS (both in budget and in research positions) has increased by about a factor of two. The number of young researchers that can be hired into CNRS positions each year has grown from 10 to 20 in that period, and the research budget has grown from F7 million to F13 million (F13 million = about \$2.5 million at September 1990 rate of exchange), exclusive of salaries.

Salaries for the approximately 250 mathematicians employed in CNRS laboratories are paid by the part of CNRS responsible for personnel (awards for research do not include salary support). This growth since 1987 is only the first stage of the CNRS plan to develop mathematics. Over the next 2-3 years, mathematics will grow at a rate that is greater than the overall growth rate for other fields. However, the number of new mathematicians entering CNRS will remain at 20, in the optimal case. To take in a greater number might put an undue burden on the recruiting of mathematicians at universities. To take fewer would result in a shortfall of mathematicians required for work on a variety of existing and planned CNRS projects.

Some specific ideas are being considered to continue the development of mathematics support at CNRS. These include the previously mentioned planned budget increases and development of mixed research units (unités de recherche mixtes). These units will be supported in equal shares by CNRS and by industry. Finally, and still in the discussion stage, is the development of independent CNRS mathematics research institutes. If the idea is approved, the first of these would concentrate on research at the interface between mathematics and computer science, and it would be located near Marseille. Such institutes will cost about F1 million annually (as opposed to the F200,000 per traditional research unit), so the commitment will be a major one. The CNRS must consult on the development of these institutes--and, indeed, the whole program of mathematics development--with the universities to avoid problems that may arise in the deployment of mathematicians.

Over the past 20 years, teaching at French universities has become more demanding and less rewarding (in the personal, not financial, sense). The CNRS is responding to this situation by trying to make available additional support for research and release time for those professors who want to perform research temporarily. In 1991, CNRS will begin to provide temporary positions for such professors in CNRS research units. Four to five such positions will be available each year for periods of up to a few years. Most of the 45 CNRS research units are located in universities. In most cases, these groups of two or three people receive about 40 percent (around F200,000) of their support from CNRS and about 60 percent from the university with which they are associated. The CNRS provides about F10 million for these units, primarily for such things as journals and books, small computers, and support for visiting researchers (including foreign researchers). Mathematicians who leave CNRS typically do so before about age 35 to teach at the universities where salary and promotion opportunities will be greater.

Projects which will require funds beyond the normal subvention get about F3 million annually from CNRS. These activities include support for a Center for International Research on Mathematics (CIRM) which hosts national and international meetings, support for research on a special theme identified for support each year (last year dynamic systems), some support for the Mathematics Society, and small supplemental assistance to international cooperation in research. The CIRM receives F1 million from CNRS and F1.5 million from the Ministry of Education. The support for international research cooperation encompasses two tasks that are of high priority:

- Increasing the number of mathematics projects which can be supported under the NSF/CNRS cooperative program
- Supporting cooperation with Eastern European and Soviet mathematicians.

The latter endeavor is aimed at supporting activities that will enable researchers in the East to have excellent opportunities for cooperation with French researchers without permanently leaving their home country research community. There are active cooperative programs with researchers in the U.S.S.R., Romania, and Hungary.

Conclusions

For the future, French mathematics must consider that mathematics and theoretical physics are merging, and links at the margin with computer science must be strengthened. Computer science wants to be independent, and will likely be linked to all sciences. The mathematics/computer science interface is shifting, with some aspects of computer science coming to be dominated by applied mathematics. In addition, numerical analysis applied to problems of industry will require physics as well. The CNRS should help workers in these fields to work together, including on problems of industry. In Nice, a mixed unit consisting of mathematicians, applied and experimental physicists, and theoretical physicists (including an American) is being set up to study nonlinear phenomena.

Seventy-three percent of all French mathematics units are located in the Paris area. As part of CNRS's modernization plan, CNRS units can expect to undergo some dispersal to other areas in France. If they materialize, the independent research institutes will be the most important element in the mathematics community for accomplishing that end.

International Colloquium on Automata, Languages, and Programming

by J.E. Savage, Department of Computer Science, Brown University, Providence, Rhode Island

The European Association for Theoretical Computer Science sponsors the annual International Colloquium on Automata, Languages and Programming (ICALP). In July 1990, the 17th in this series of conferences was held at Warwick University, Coventry, UK. Papers were invited from all areas of theoretical computer science including algorithms, automata theory, computability, computational complexity, computational geometry, concurrency, cryptography, data structures, data types, databases, knowledge bases, formal languages, logic programming, logical design, parallel and distributed computation, program specification, transformation and verification, programming language semantics, robotics, symbolic and algebraic computation, term rewriting systems, and VLSI layout.

Invited talks were given by David S. Johnson, AT&T Bell Laboratories, Murray Hill, New Jersey, Neil D. Jones, University of Copenhagen, Jan W. Klop, CWI, Robin Milner, University of Edinburgh, and Kurt Mehlhorn, University of Saarland, Saarbrücken, Federal Republic of Germany.

The ICALP is an international meeting with a European cast. Eleven of the fourteen program committee members were European, two were American, and one was Israeli. More than 55 percent of the papers were presented by authors from Europe and the Soviet Union; the U.S. was the next largest group represented, with about 30 percent. Other nations represented were Canada, Israel, and Japan.

The program was as diversified as the list of topics given above would suggest. Seventeen sessions were held on themes that included algorithms, computational complexity, computational geometry, concurrency, languages and automata, learning, process models, term rewriting, and type theory. With such a diverse program, the invited talks provided useful and important overviews.

Prof. Mike S. Paterson, University of Warwick, did an excellent job of chairing both the program and local arrangements committees for the meeting. The program was interesting and the conference center at the University of Warwick was comfortable, convenient, and inexpensive. Attendees were largely confined to the campus because of its distance from the neighboring town of Coventry, and thus created many opportunities for interaction. In the tradition of ICALP conferences, several planned social events were also offered. They included a visit to the Coventry cathedral destroyed by air raids during World War II and a banquet at a nearby abbey.

The ICALP conference provided many opportunities for theoretical computer scientists from several continents to interact in a casual environment. The proceedings have been published as *Automata Languages and Programming, Lecture Notes in Computer Science, Number 443*, Springer-Verlag, M.S. Paterson, Editor, Department of Computer Science, University of Warwick, Coventry, CV4 7AL, United Kingdom.

Symposium on Boolean Function Complexity

by J.E. Savage

Introduction

In summer 1990, the London Mathematics Society (L.M.S.) sponsored a by-invitation-only symposium on Boolean Function Complexity held at Grey College, Durham, England. Professor Michael S. Paterson, Department of Computer Science, Warwick University, England, organized the symposium and assembled a program committee including himself, Dr. William F. McColl, Oxford University, and Prof. Andrew C. Yao, Princeton University, Princeton, New Jersey.

A fundamental topic in theoretical computer science, Boolean function complexity was an excellent and timely theme for this 10-day meeting. Important new results have been obtained in the last 10 years, yet no international meeting devoted entirely to this subject has been held during this period. The participants included a broad spectrum of early and late contributors to Boolean function complexity from Eastern and Western Europe, Canada, Israel, the Soviet Union, and the U.S.

Boolean functions $f: \{0,1\}^n \rightarrow \{0,1\}$ describe computations on digital machines in a natural way. The size and depth of circuits to realize Boolean functions, stated in terms of the number n of inputs to a function, provide fundamental lower bounds on conventional complexity measures; e.g., time and space on serial and parallel machines. The importance of Boolean function complexity is emphasized by the widely shared belief that the question whether or not $P = NP$ may be resolved using this measure.

The derivation of lower bounds on the size and depth of circuits for non-trivial functions is a daunting task except under special conditions. For general circuits, we have not produced better than linear lower bounds on circuit size or better than a multiple of $\log^2 n$ circuit depth despite the fact that most Boolean functions on n inputs have size and depth proportional to $(2^n/n)$ and $O(n)$, respectively. By general circuits, we mean those constructed through functional composition of operations from a set rich enough to permit all Boolean functions to be computed. Such sets are called complete bases; the set (AND, OR, NOT) is complete. The basis

elements in a general circuit must also have a bounded number of inputs or "bounded fan-in".

Lower bounds on size and depth for general circuits provide lower bounds on time and space for general models of computation, such as the random access machine (RAM), the Turing machine, and parallel versions thereof, but require that the circuit bases be complete and that the fan-in be bounded. However, the difficulty of deriving strong lower bounds on circuit complexity for general circuits has caused complexity theorists to study incomplete bases and bases with unbounded fan-in. They hope that these studies will help identify the information needed to derive better bounds for circuits of bounded fan-in over complete bases.

Presentations

More than thirty talks were given at this 8-day meeting on a large range of topics. Circuit size, formula size, and circuit depth for monotone Boolean functions over the monotone basis (AND, OR) figured prominently. Recent exponential lower bounds on circuit size; e.g., for the NP-complete CLIQUE problem, and polylogarithmic bounds on depth; e.g., for st-connectivity, for monotone functions over the monotone basis were presented. Functions such as the permanent have been shown to require exponential size over the monotone basis but only polynomial size over complete bases (negation converts the monotone basis to a complete basis). Several other talks on monotone Boolean functions and their classifications were presented.

Constant-depth, unbounded fan-in circuits were also the subject of several talks. In the last 10 years, several problems; e.g., parity, have been shown to have exponential-size, constant-depth circuits. Reports were given on recent techniques for the classification of Boolean functions computable in bounded depth as well as complexity classes defined by constant depth over increasingly powerful bases. Also reported were concrete results showing that certain problems can be computed efficiently in constant depth.

Boolean function complexity has been studied using other models of computation; e.g., finite-width branching programs, communication between two players, and contact networks. Also studied was circuits with restrictions; e.g., planarity and input values that are read-once. Talks were given on all these topics. Many other topics were covered, including time-space tradeoffs, efficient circuits for concrete problems, the complexity of restricted classes of functions, and neural networks.

The Cambridge University Press will publish papers from this symposium in the L.M.S. Lecture Notes Series under the title Boolean Function Complexity.

Summary

The setting, a small residential college at Durham University, was an excellent venue for the meeting. Participants lived in dormitory rooms, took their meals together in the refectory, and gathered in the afternoon and evening in a junior commons room, all of which encouraged interaction. The beautiful old town of Durham, graced by a magnificent Norman cathedral and a Norman castle, is a short walk away; it provided opportunities for exercise and occasional local sightseeing. Two outings were organized--an afternoon walk to Durham with guided tours of the Durham cathedral and castle, and a day-long visit to Hadrian's Wall. Both outings provided welcome breaks to the 5-6 hours of daily lectures.

The meeting was considered a great success by all. It was an opportunity to put the many recent contributions to Boolean function complexity into perspective, to get acquainted with recent contributors, and to renew acquaintances with older contributors. The field has made important advances in recent years but it is clear that many very hard problems of great importance remain.

The European Common Community Approach to Permanent Magnetics

by Howard Lessoff, a physicist serving as Liaison Scientist for solid-state chemistry and physics at the Office of Naval Research European Office. Specializing in crystal-growth and material sciences dealing with electronics and opto-electronics, he was formerly Head of the Electronic Materials Branch, Naval Research Laboratory, Washington, D.C.

Introduction

Permanent magnets are widely used in motors and generators, loudspeakers and other acoustic devices, as well as many mechanical applications from bearings to simple holding devices. From the earliest iron-based alloys to the samarium cobalt alloys, there has been a steady improvement in the magnetic properties. Energy products of the samarium cobalt alloys have been reported in excess of 30 megagauss oersted (MG Oe). The use of the cobalt materials has not been widely adopted for commercial applications. The limited use of the cobalt magnets is because of both the cost and the potential political situations which have previously interrupted the cobalt supply. Noncobalt magnetics, such as the nickel iron alloys (ALNICO), are widely used. These alloys have lower energy products thus limiting the potential applications. Other permanent magnet materials in wide use are based on the barium ferrite. The ferrites have received wide usage ranging from door latches to pole pieces in low-cost motors. There is still a need for lower-cost permanent magnets having higher energy products.

In the mid 1980s, a new permanent magnet was discovered in both the U.S. and Japan. The new magnet is an alloy of boron, neodymium, and iron (Nd-Fe-B). The alloy does not contain cobalt. Many of the alloy's magnetic properties are equal or better than the Sm-Co alloy. Reported energy products for the Nd-Fe-B alloys are more than 40 MG Oe. Thus, the Nd-Fe-B alloy would be useful in many new applications and could replace both the barium ferrite and Sm-Co magnetics. There have been serious problems with the Nd-Fe-B alloys, including poor temperature properties as well as environmental instability. The low Curie temperature of 350°C means that the magnets cannot be used in applications where the operating temperature is greater than 80°C. Another limitation is the low corrosion resistance of the Nd-Fe-B alloys. The materials readily oxidize when exposed to air, and means are required to protect the material during processing and use. Thus, applications of the early Nd-Fe-B magnets for motors and generators were limited. In spite of the limitations, there was a rapid transition to production. The 1988 production of Nd-Fe-B magnetics was in excess of 700 T/yr, Japan having the main market share. The EC recognized very early the potential for noncobalt containing permanent magnets and in particular the Nd-Fe-B material.

As a result, cooperative research activity was initiated in 1985 to develop the new permanent magnets to replace the cobalt permanent magnetics under the auspice of European Research in Advanced Materials Basic Research in Industrial Technologies for Europe (BRITE/EURAM). The program is part of an overall European effort and is called Concerted European Action on Magnetics (CEAM). The program is coordinated and sponsored by the Commission of European Communities. The project manager is Dr. I.V. Mitchell, DG XII-C4 EURAM, 200, rue de la Loi, B-1049 Brussels, Belgium. The effort includes about 60 laboratories in nine countries within the EC and Austria.

The effort consists of a cooperative initiative between industry (about one third of the activities), universities, and government laboratories. The largest members of the program are the U.K., France, and the Federal Republic of Germany. Each of the latter two having an equivalent number of participating laboratories. The CEAM is divided into three disciplines: materials, magnetic processing, and applications.

CEAM Organization

Prof. J. Michael D. Coey, Trinity College, Dublin, directs the materials activities. This team is the largest with 29 cooperating laboratories. The work consists of phase resolution, new material investigation, and determination of both extrinsic and intrinsic properties. The team at Trinity College announced a new alloy

consisting of samarium-iron-nitrogen (Sm-Fe-N). The Sm-Fe-N magnetic properties that are superior to the Nd-Fe-B compounds. Recently, the Siemens group reported the Curie temperature of $\text{Sm}_2\text{Fe}_{17}\text{N}_3$ to be 170°C . The higher Curie temperature should allow use up temperatures as high as 250°C . This would expand the usage of the new magnets to many applications (especially in the transportation field), including direct current motors and generators.

Prof. I.R. Harris, University of Birmingham, heads the processing group. The group has the responsibility to find methods of preparing the new alloys into forms that are useful in manufacturing and enhancing the material stability. Of the 15 activities engaged in the processing group, 11 are industrial firms. The majority are within the U.K. Among the major programs are increasing the temperature stability, improving processing, and improving corrosion resistance. If the materials are to be commercially viable, then solutions to the processing and stability programs must be solved. New manufacturing steps have been developed that have resulted in improved processing stability. The group, under Prof. Harris, has made significant progress in the preparation of fine powders via the Hydrogenation-Disproportionation-Desorption (HDD) process. The use of new alloys, including vanadium additions, has resulted in improved corrosion resistance. The vanadium forms a vanadium-ferrium-boron (V-Fe-B) precipitate which apparently reduces oxidation.

Prof. R. Hanitsch, Technische Universitat Berlin, heads the application efforts. The properties of the Nd-Fe magnets are such that new designs must be developed for both static applications and moving applications. The lower cost of the Nd-Fe magnets and the higher-energy product will increase the usage of the materials in high-power motors and rotary equipment. This activity includes both design and prototype manufacture. Among the design improvements are a compact alternator which can also be used as a brushless starter motor and stepper motors using radically magnetized bonded Nd-Fe-B-embedded magnets.

The successes of the CAEM I program (a renaming of the original CAEM program) has resulted in the formation of a second activity called CEAM II which is scheduled to last to early 1993.

Semiconductors--Back to the Future

by Howard Lessoff

Is the semiconductor industry returning to the earliest of semiconductor materials? The current age of solid-state electronics began with the demonstration of a germanium (Ge) transistor at Bell Telephone Laboratories. Germanium was used since the ability to prepare the pure element was relatively simple when compared to other candidate materials. Early transistor radios and other devices were made using Ge transistors. With the introduction of silicon (Si) semiconductor technology, Ge solid-state devices became the past, and are now used in specialty devices such as detectors. Now of course, there are a wide range of semiconductor materials. From this catalog of materials, the device engineer can choose the materials that best suits his needs.

Silicon is, and will continue to be, the predominant material for devices and integrated circuits. Silicon is easy to process, has a native stable insulating oxide, and is quite robust mechanically when compared to most other semiconducting materials. A major disadvantage of Si is that it does not have a direct bandgap; thus efficient light-emitting devices are not feasible. The semiconductor III-V materials such as gallium arsenide, and indium phosphide have properties not available in silicon, including a direct bandgap and very mobile electrons. Having direct bandgaps, the III-V semiconductors are used for light-emitting devices such as solid-state lasers and diodes. Electrons move very rapidly in the III-Vs when compared to electron movement in silicon. The III-Vs are used in high-speed digital, microwave, and millimeter wave technology. Do these properties allow one to project that the III-V materials will play an increasingly large role in the electronic and optoelectronic industry?

Semiconductors can now be custom-grown atomic layer by atomic layer using such techniques as atomic-layer epitaxial, molecular-beam epitaxy, and organometallic-chemical deposition. New types of material structures are being explored that have stacks of submicron layers of various materials. The stacked layers of materials do not have exact lattice-matching to each other; therefore, strain exists between each layer of the material. The ability to control layer size, strain, and the types of atoms within the layers now allows the tailoring of the semiconductor properties, including the bandgap.

By controlling the growth of layers of Si and Si/Ge alloys, many research laboratories world wide are beginning to realize that new types of devices are possible. These devices have operated in the high-millimeter region, approximately 100 GHz. The Royal Signals and Radar Establishment has demonstrated orange light emission at room temperature from silicon quantum wires. Thus those applications, which were considered to

be the domain of the III-V semiconductors, are now being challenged by the combination of the two earliest semiconducting materials: Ge and Si. Whether the use of Si and Ge will relegate the III-V and II-VI materials to a niche market remains to be seen. If the properties of direct-bandgap semiconductors in Si or Si/Ge are achieved, it will be a major leap in bandgap engineering. But there are a lot of laboratories trying. Oh well--back to the future!

ONREUR REPORTS AND MAS BULLETINS

Reports

To request reports, indicate the report number on the self-addressed mailer and return it to ONREUR.

Aerospace

European Space Developments and Programs at the 29th Farnborough International Aerospace Exhibition, by CDR Robert C. Treviño. (91-1-C) This report is based on the 29th Farnborough International Aerospace Exhibition, the largest aerospace event of 1990. This major biennial aerospace event is organized by the Society of British Aerospace Companies and emphasized that the trend is toward more international joint ventures among European space organizations and companies. International space cooperation both in the scientific and commercial areas will continue, but European space autonomy in manned and unmanned programs is the long-term goal.

Biotechnology

Immobilized Cell Research, by K.E. Cooksey. (90-7-R) This report is based on two meetings held in Europe in December 1989, and April 1990, as well as Dr. Cooksey's observations. Specifically, the meetings were: (a) "Physiology of Immobilized Cells" held in Wageningen, the Netherlands, and organized by the European Federation of Biotechnology and the Agricultural University at Wageningen; (b) "Immobilized Cell Processes" organized by the Society for General Microbiology of the United Kingdom at Warwick University. Proceedings of the first conference will be

available in late 1990 from Elsevier. The second conference will not be published. The general interest in biotechnological production systems using fixed-cell reactors is increasing. Two similar meetings being held in less than 6 months is a strong indication of the interest. Although these meetings dealt specifically with the biotechnological side of cellular immobilization, there are aspects of this research that have importance in other fields.

MAS Bulletins

The following Military Applications Summary (MAS) Bulletins were published between October 31, 1990 and February 15, 1991. The MAS Bulletin is an account of accomplishments in European naval research, development, and evaluation. Request copies by number from ONREUR.

- 20-90 Meteosat Weather Data and EUMETSAT Polar Systems Program
- 21-90 A Real-Time System for Transmitting Satellite Data Products to Icebreakers
- 01-91 Bofors Presented at the Bofors Effect Symposium 90
- 02-91 Harwell Tests New Legionella Killer System
- 03-91 Underwater Scaffolding
- 04-91 MAS Bulletin 1990 Annual Index

REPORTS ON EUROPEAN SCIENCE AND TECHNOLOGY FROM OTHER COMMANDS

Reports

Information on each of the reports listed below was furnished by the following activity. Address requests to:

EOARD - European Office of Aerospace Research and Development, Box 14, FPO new York 09510

Production Engineering and Materials Research at Catholic University, Leuven, Belgium, by Dr. Vince Donlan, EOARD. (12pp)[EOARD-LR-90-048]

Production Engineering research at Catholic University deals with production processes, machine and instrument design, structural dynamics, acoustics, CAD/CAM/CIM, robotics, assembly automation, and metrology. This report describes several ongoing projects: filament winding of composites; electrodischarge machining; force, torque, and tactile sensors; finite element modeling with AI; active control of vibrations; modeling of mechanical joints; active control of noise; modeling of acoustic noise in enclosed spaces; CAD programming; flexible process planning; robotic grippers; autonomous mobile robots; flexible assembly cells; and calibration and error correction in coordinate measuring machines.

The Department of Metallurgy and Materials Engineering is the largest materials research group in Belgium. Research is conducted in new materials development, surface science and technology, plastic deformation and mechanical behavior of materials, nondestructive testing, and expert systems. Several ongoing research projects are summarized in this report: development of shape memory alloys, microgravity processing of MMC, Al-Li alloys, explosive compaction of nickel aluminides, high-temperature superconducting materials processing, and an expert system for materials selection and corrosion prevention.

Advanced Research in Optical Systems, Neural Networks, and Antenna Design, by LTC Parris Neal, EOARD. (3 pp)[EOARD-LR-90-051]

Weizmann Institute of Science (Weizmann), Rehovot, Israel, performs extensive research in several fields. I talked with members of the Department of Electronics whose interests lie in optics, neural nets, and microstrip antennas. Holographic elements that are more invariant to rotation and scale have been developed. Researchers at Weizmann designed an incoherent light optical correlator for image identification and Israeli Aircraft Industries built a prototype. This department has also designed and constructed an all-optical Hopfield neural net, as well as conducted research into micro-strip antennas.

Westland Aerospace, by LTC James G.R. Hansen, EOARD. (8pp)[EOARD-LR-90-053]

Westland Aerospace (UK) has assessed thermoplastic matrix composite (APC2) cryogenic tanks for space transportation vehicles. They have measured material tensile strength following cryogenic preconditioning in LOX and LN. Additionally, they have fabricated representative cryogenic tank structure (APC2 faceplates with foam core) and tested it for thermal shock and insulation properties. Explosive cracking occurred during thermal shock of three of four different designs of tank structure. However, this cracking did not show up in coupon immersion tests. Representative structure for cryogenic tanks of hypersonic vehicles, such as NASP, should be tested for thermal shock at cryogenic temperatures.

Biotechnology and High Technology at Two Universities in Athens, by LTC Chet Dymek, EOARD. (6 pp)[EOARD-LR-90-055]

At the National Technical University of Athens, a big investment has been made to enhance an active program in biotechnology. Stemming from trying to solve Athens' pollution problems, Prof. Valkanas' group is now tackling other areas; e.g., efficient conversion of cellulose materials to high-quality fuels, obtaining cheap high-modulus fibers from solubilized cellulose material, and macroplegmatic polymers (which absorb up to 100 times their weight in target organic liquids). A computational fluid dynamics unit uses the PHOENICS code in work on flows coupled with heat transfer and chemical reaction.

The Theoretical and Physical Chemistry Institute of the National Hellenic Research Foundation has high-quality research programs in the theoretical treatment of new high-energy content systems for advanced propulsion. At the same time, they are conducting a range of high-technology, laser-based experiments.

Chemistry at the University of Padua, by LTC Chet Dymek, EOARD. (10 pp)[EOARD-LR-90-056]

The University of Padua has institutes jointly operated with the Italian National Research Center. One of these is the Institute of Industrial Chemistry directed by Prof. Umberto Belluco. A major area of research is in transition metal complex chemistry. They work on Pt complexes that are used to convert olefins to epoxides, and on the cyclization of coordinated ligands. A very interesting and unique collaborative project is the attempt to exploit the synergism of polyphosphazine polymers with grafted organic polymers and/or

organometallic substituents. Other groups work in biotechnology of thermophilic proteins, and spectroscopic and theoretical studies of the interactions of electrons with the vibrations in solid organics (TTF, TCNQ, and BEDT-TTP).

Clocks, Cooling, Curing, and Cracks at the University of Pisa, by LTC Chet Dymek, EOARD. (17 pp) [EOARD-LR-90-058]

At the University of Pisa, Professor Strumia heads a laser and spectroscopy group that probes the sometimes bizarre behavior of atoms and molecules in laser systems. Laser cooling and the nonlinear Hanle effect are two of their favorite phenomena. They also have a pioneering attitude towards applications ranging from atomic clocks to soft x-ray lasers based on metastable helium.

Prof. Butta heads the Department of Chemical Engineering which has an active polymer research group. In collaboration with the Department of Physics, they are investigating the kinetics of curing of epoxies using dielectrometry. They are also studying methods of reinforcing thermosets with elastomeric particles to stop crack propagation.

Science in Hungary, by COL Jay Schuman, EOARD. (12 pp) [EOARD-LR-90-062]

Members of EOARD recently visited several sites associated with aerospace research for the Hungarian armed forces. This report explains research activities at

the Military Technical Institute (MTI) and Central Institute for Physics (KFKI). At MTI, we were briefed on how the Hungarian armed forces organize their research and development activities. The MTI provided some insights into the subsystems they have developed over the years for use by the Hungarian and Soviet armed forces. In particular, the MTI has been involved in developing small arms and electronics equipment.

At KFKI, we were shown their research primarily in electronics and physics. Hungary is rebuilding the infrastructure. Concurrently, Hungary would like to gain a foothold in western markets.

Neutron Instrumentation Systems for Aeropropulsion System Testing, Rolls-Royce, by LTC Fred Gilliam, EOARD. (11 pp) [EOARD-LR-90-063]

A team of researchers at Rolls-Royce plc, Bristol, U.K., have developed novel and powerful instrumentation systems for nonintrusive, on-line measurements of tip clearances, temperature, and strain of turbojet engine components. The system uses a beam of neutrons as the sensor. Analysis of the scattering from the beam provides engine component strain measurements and temperature measurements accurate within 0.4K in 1,000K. The technique could be adapted to make similar measurements in other engineering applications.

THE EMBASSIES: TECHNOLOGY ROUNDUP

Federal Republic of Germany

For further information on FRG items, contact Mr. Edward M. Malloy, Science Counselor, American Embassy, Bonn, APO New York 09080-7400.

Government Funds Clean Coal Technology

Clean coal technology research in the Federal Republic of Germany (FRG) is funded under the auspices of the Federal Ministry of Research and Technology's (BMFT) third energy research and technology program. This umbrella program provides the framework for the complete spectrum of energy research and development (R&D) through 1993 and has a budget of DM 5.0 billion (\$2.85 billion). The program's focus is nonpollutive energy technologies. Clean coal technology R&D is a significant part of this program, funded at about DM 550 (\$314.3 million). Coal will continue to be the FRG's greatest energy resource and the increasing environmental problems associated with fossil fuel utilization give priority to clean coal R&D.

France

For further information on France items, contact Dr. Michael Michaud, Science Conselor, American Embassy, Paris, APO New York 09777.

Oceanography: New and Proposed Research Vessels

During recent months, the French Oceanographic Agency IFREMER has deployed two important vessels: the large surface research ship *Atalante* and the industrial submarine *Saga*. In addition, IFREMER continues to push for a next-generation European Oceanographic Research vessel called NEREIS. Along with older IFREMER vessels, *Atalante* and *Saga* give France capabilities that place it among the world's leading nations in oceanography.

France has a well-established reputation for excellence in civilian ocean technology and continues to devote significant resources to this field. Along with older IFREMER vessels, *Atalante* and *Saga* give France capabilities that place it among the world's leading nations in oceanography.

Italy

For further information on Italian items, contact Gerald Whitman, Office of Science Conselor, American Embassy, Rome, APO New York 09794-9500

JESSI ITALIA--part of Joint European Silicon Submicron Initiative

The Italian minister for university and scientific research announced the creation of an Italian consortium called JESSI ITALIA. The consortium will promote and coordinate Italian participation in the Joint European Silicon Submicron Initiative (JESSI). JESSI ITALIA is formed by SGS-Thomson and 11 other Italian electronic companies. Also cooperating are the Italian National Research Council (CNR), the Italian National Agency for Nuclear and Renewable Energies (ENEA), and eight universities. These entities are cooperatively managing the 400 billion Lire (about \$348 million) of a 6,000 billion Lire total that the Italian government will contribute in 8 years for its participation in JESSI. Nine European countries are sharing the cost, and they are represented by over 100 companies and research organizations.

New U.S./Italy Rocket Venture

A new advanced industry factory, TAEMA (Advanced Technology and Materials) was recently inaugurated in the town of Avellino (southeast of Rome). The factory is the result of a joint venture between BAT international and Hercules Incorporated (U.S.). The final goal of the new industry is the future manufacturing of the space rocket PEGASUS, which is expected to launch payloads at half of the present costs without needing the support of a launching range.

Biotechnology Center

The Italian government is building a National Center for Advanced Biotechnology (Center) in Genoa. The Associazione Nazionale per le Biotecnologie Avanzate (National Association for Advanced Biotechnology) was recently formed. The organization will evaluate and propose research programs for the Center; also, it will establish its organization and management. The Center will favor basic research and its transfer to industry, prepare a new generation of researchers in biotechnology, and offer services and expertise to research organizations, universities, and industry.

Joint Venture for Electric Auto Batteries

The Italian National Agency for Electricity (ENEL) has recently promoted the research and development of new batteries for electric automobiles. Through CESI, its experimental laboratory for electronics, ENEL will study jointly with Magneti Marelli and Ginatta a new type of battery to be used by electric automobiles in urban areas. The research will focus on two types of batteries--sodium-sulphur and lithium-aluminum and sulphides--based on an electrochemical technology using melted salts as electrolyte. The goal of this project is to produce for the market in less than 4 years the first battery capable of an autonomy of over 200 km, producing a speed nearing 100 km/hr, rechargeable for about 1,000 times.

Stratospheric Balloon Campaign

The Italian National Space Agency (ASI) (in cooperation with the French space center in Toulouse and the Spanish National Institute for Spacetechnology [INTA]) has started the 1990 stratospheric balloon campaign by launching the first balloon from Milo air base, Sicily. Normally, these balloons reach the altitude of 40 km with their payloads. They can measure the infrared radiation emissions between 3.5 and 11.3 m of the ultraviolet sunrays and the extragalactic radiation in the infrared wave. The cooperative venture will also conduct research to verify if it is possible to launch a large size balloon transporting a weight of 2.5 tons. These balloons fly for about 18 hours, and they are normally collected in southern Spain. In many instances, stratospheric balloons are replacing satellites. They can conduct research measurements at altitudes slightly higher than the earth's atmosphere at minor cost. Many experiments performed by stratospheric balloons are done in preparation of more sophisticated experiments later carried out by satellites. Unfortunately, the first balloon launched (AROME) met with a layer of high temperature at 22 km of altitude and burst open. The 900-kg payload was supported by a parachute and landed in the sea where it was retrieved unharmed the next day.

Atherosclerosis Plaque Treated with Ultrasounds

In 1987, the National Council Research Institute of Clinical Physiology and the Institute of Medical Pathology of the University of Pisa started to study a new method to eliminate atherosclerosis plaque formed in the arteries. The experiment uses the smallest size of catheters (less than 2 mm in diameter) equipped at the top with a microgenerator of ultrasound. On anatomical samples of aorta, the device can destroy plaque with a minimum application of 25 sec to a maximum of 40 sec without damaging the arteries. The experiment has been patented and the Italian Ministry of Health is supporting the manufacture of a prototype for intravascular use that can be introduced into the coronary arteries.

National Research Programs

The National Research Programs are sponsored and managed by the Ministry of University and Scientific Research. They represent a way to promote scientific research in industry for production areas that will help Italy compete in the world market. The programs award research contracts. The state gets the research results, gives it to industry to exploit, but keeps the ownership of the patents. The following six national research programs are operating:

1. National Research Program on Bioelectronics Technology. Research areas are

- Protein engineering
- Neuronal microelectronics

2. National Research Program on Advanced Innovative Materials. Research areas are

- Structural materials
- Thermomechanics
- Superconductors
- Electromagnetics
- Biomaterials

3. National Research Program for Chemistry. Aim is identifying new industrial chemical processes that would consider

- Environmental protection
- Human health protection
- Monument and works of art preservation.

4. National Research Program on Microelectronics. Continues to develop VLSI silicon-integrated circuits and manufacture 1-megabit epron memory.

5. National Research Program on Advanced Biotechnology. Active in

- Health
- Chemistry
- Energy
- Environment
- Food production

6. National Research Program for Cardiac Technology. Priority areas are

- Artificial heart
- Cardiac prostheses

Urban Wastewater Largely Unpurified

The Italian National Institute of Statistics conducted an investigation on the number of purifiers for urban wastewater that city administrations have built and are operating since the application of the Italian law on clean water (approved in 1976). In Italy, 56.5 percent of local administrations have not equipped their sewage treatment plants with purifiers as required by the law, and completely untreated wastewater is dumped into rivers and the sea.

Monteco Operates Environmental Research Center

The private chemical industry Montedison created Monteco, an environmental services company. Monteco has inaugurated in Ferrara a research center for the environment with an initial investment of 20 billion Lire (about \$17.4 million). The center will serve the industries of the Montedison group for environmental research purposes. Also, the center will be available to carry on studies and research contracts for other companies and public and private organizations. One of the center's buildings is occupied by laboratories specializing in the analysis of hazardous substances present in minimal traces in the environment and termed as micropollutants. These laboratories will be able to spot and identify pollutants present in liquids, earth, and air in quantities otherwise impossible to detect. The center building will house an experimental center for the recycling of heterogeneous plastics especially present in urban waste. According to the Monteco's manager, the center is the most advanced in Italy for this type of environmental research activity.

Tuscan Industry Recycles Carbon Dioxide

Tioxide International, located on the Tuscan Coast, is producing titanium dioxide at the rate of 88,000 tons/yr with more than 50 percent of the production destined for export. Until 1984, the residual sludge of the company was dumped in the sea, tinting the coast and the sea a reddish color. Since 1985, the company has treated the titanium sludge to make them into chalk cakes to be used in agriculture.

Also, Tioxide International and Societa' Anidride Carbonica Italiana inaugurated new equipment that regenerates the carbon dioxide (CO_2) produced during the working of the titanium. The CO_2 is purified, compressed, and liquefied, which makes it ready for market. It is estimated that Italy annually uses industry about 140,000 tons of CO_2 . These initiatives of Tioxide International were cited by Greenpeace as an example of intelligent management to be followed by other companies.

ENEL for Environment

The ENEL has committed to drastically reduce the sulphur dioxide emitted in the air from coal-fired powerplants.

Ozone Monitoring

Managed by the local university and the National Institute of Geophysics, the first station for the monitoring of ozone in the Northern Hemisphere started operating near the city of L'Aquila. The station is working with a lidar or optical radar and is capable of detecting the concentration of ozone at altitudes ranging from 15 to 30 km. NASA selected the station to be a comparison center for data to be collected by a future upper atmosphere research satellite. Also, the station will be part of the network for detecting stratospheric changes that NASA and the world meteorological organization promote.

The Italian National Research Council

The CNR has completed one year of an ambitious 5-year program to develop a broadband integrated services digital network (B-ISDN) system in Italy. The program, which remains in the early planning and theoretical stage, is a cooperative effort between the Italian government, industry, and universities.

Project manager, Aldo Roveri, says the entire project remains in the theoretical and early planning stages does not foresee any practical application before 1995. For example, the ATM computer system has not been practically employed to date.

The CNR has provided 78 billion Lira (about \$69 million) to the project with additional funding coming from Italian universities and industry. For example, in the first year, universities provided 2.5 billion Lire (about \$2 million) and industry provided 16 billion Lira (about \$19 million). According to the Roveri, in the first year, 30 percent of the project staff came from national research centers (universities and public/private research laboratories) and the remainder came from private industry. Major university participation includes the universities at Florence, Pisa, Bari, Padova, and Naples.

Roveri emphasized the project's general objectives are to

- Acquire the necessary knowledge to develop a broadband communication network and services system according to nation plans and European strategic choices
- Integrate Italian National Research into one advanced project
- Promote the formation of highly qualified technicians in an innovative environment.

The CNR project has five major areas of activity:

1. Structure of broadband communication network which includes the role of satellite system for high-density TV
2. Technologies for broadband optical communications concerning the experimental studies of some optical technologies in the context of B-ISDN development.
3. Terminals and signal processing in ATM network (Asynchronous Transfer Mode)
4. Access and switching techniques for broadband networks to create a flexible experimentation environment
5. Experimental realization of broadband communication networks with the aim to implement some broadband integrated networks in urban areas and to experimentally employ new communication services.

American and Italian Review Science and Technology Cooperation

Recently at their biannual American/Italian science and technology (S&T) review meeting, participants concluded with a suggested program of cooperation in 12 areas. New areas not previously considered were global climate change and advanced materials research. At a special concluding seminar on the importance of European Community S&T cooperation, all sides agreed that bilateral science relations would remain important after 1992. The attendance of high-level Italian science and political figures in the conference sessions and the representational events lent impressive evidence to the importance that Italy attaches to bilateral science cooperation with the U.S. Discussion during a site visit to the Gran Sasso High-Energy Physics Laboratories exposed difficulties in financial support of American participants.

Fewer Fish in the Adriatic Sea

According to data revealed during the 25th European meeting of marine biology held in Ferrara, the quantity of fish in the Adriatic Sea decreased 10 percent in the last 5 years. The causes of the decrease in Adriatic fish stocks are being attributed to the increase of the temperatures of the air and the water. Another cause is the decreased flow of water from rivers bordering the Adriatic caused by the last 2 years of drought.

Italy Increases Pollutants in the Air

The Italian National Hydrocarbons Agency (ENI) released a study on pollutants in the air revealing an increase of 273 percent, much higher than the world average. Italy's emissions in the air are 10.27 million tons, 2.6 percent of the world total. In 1988, 6 million tons of carbon monoxide, more than 2 million tons of sulphur

dioxide, and 2 million tons of nitrogen oxides were dumped.

ENEL Implements Desulphurization

The ENEL has awarded to a consortium (Ansaldo and CIFA) a contract of 610 billion Lire (about \$530 million) for desulphurization of fumes produced by coal-fueled powerplants. In total 7,500,000 cm/hr of emissions will be treated with a 95 percent decrease in sulphur dioxide. Part of the financing will support research into the stocking of chalks produced by the fume absorption apparatus.

ENEL Treats Low-Level Radioactive Solid Waste

The ENEL is experimenting with a method for the disposal by combustion of two-level radioactive resins produced by nuclear powerplants. The process is being tested in a plant of industrial scale where the resins are first dried in a vacuum to decrease their humidity from 60 to 20 percent at the quantity rate of 25/hr. Subsequently, they are incinerated in a device that handles 1 kg of resins/hr and produces carbon monoxide in the exhaust gases in the negligible quantity of a few tenths of ppm. The exhaust gases are then cooled from 1,050 to 230 and passed through a filter that catches suspended ashes and sulphur oxides. The residue then is treated in a system for confinement and collection. The process is intended to reduce considerably the volume of low radioactive waste for storage, is largely automated, and equipped with remote sensing apparatuses.

Institute of Environmental Research

The Italian League for Environment has created the Institute of Environmental Research (Institute). The Institute is a nonprofit organization in Milan and will have several consulting links with universities and research organizations. The Institute will be active in environmental planning, elaborating environmental data, analyzing environmental policies and public expenditure for environmental problems, studying clean technologies, analyzing environmental risks, and disseminating public information. The Institute will work independently as well as under contract from public and private organizations.

National Committee on Environmental Impact Vetoes Highway Construction

The National Committee on Environmental Impact (Committee), chaired by the Minister of Environment, vetoed construction of 94 km of highway on the Tyrrhenian Coast of Tuscany between Civitavecchia and Leghorn. The highway would disrupt the equilibrium of an environmental landscape that presents unique features in Italy. The construction would also destroy the habitat of protected species; e.g., wolf, otter, and porcupine, and a sizeable area of agricultural territory. This is the first time that the Committee has vetoed a

highway project. This may be a new trend for the power of the Italian highway construction lobby.

Since its institution in January 1989, the Committee has reviewed 45 projects and approved only 22. Six approved projects were water dikes and 16 were industrial plants, mostly intended for hazardous and toxic waste disposal. The Minister of Environment and eight other ministers have asked Parliament to extend its review time from 90 to 120 days.

Italian Companies Will Handle Warsaw Waste

A consortium--System Eco--was recently formed between the city administration of Warsaw and three Italian companies--Acqua, Enimont, and Technimon--for handling and disposing of Warsaw's waste. First, System Eco will recycle and dispose of Warsaw's urban waste. Then, System Eco will build a monitoring network for water and air and a sewage purification system similar to the one that Acqua is building in Moscow.

Italy Protects National Territory

The CNR surveyed the environmentally protected areas throughout the national territory and discovered that more than 2 million hectares (ha) are protected (equal to 6.5 percent). The central government is responsible for 7 national parks, 140 land and 5 marine reserves, and 43 wetland areas totaling 590,298 ha. Regional administrations manage 84 parks, 136 reserves, and 153 special protected areas totaling 1,360,891 ha. Finally, private groups manage 11 protected areas totaling 6,800 ha. However, a more stringent law is needed to protect parks whose preservation is threatened by uncontrolled highways and energy facilities construction.

Italy Faces EC Court for Atrazine in Drinking Water

The EC Commissioner for Environment, Ripa Di Meana, denounced Italy for not adopting the EC rules establishing the allowed maximum of pesticides in drinking water. Referring to Atrazine, Ripa Di Meana says that the regions of Northern and Central Italy (like Lombardy, Piedmont, Veneto, Friuli-Venezia Giulia, Emilia-Romagna, and Marche) have Atrazine in their drinking water in a quantity 10 times greater than the maximum allowed. Ripa Di Meana said that in 1989 Italy had allotted 575 billion Lire to clean up the aqueducts from Atrazine, but the cleanup has not been done. The Italian Minister of Environment, Giorgio Ruffolo, said that early in 1990 Italy launched an extensive program of EC-approved water reclamation. Results are now evident.

Milan Fights Smog

Milan's city administration is fighting the smog that reached dangerous level in the urban area. Milan is equipped with 248 sensors located in 110 monitoring

stations throughout the urban territory. There are no central government directives regulating the situation. Therefore, the regional administration has indicated two levels of pollution based on information received by the World Health Organization.

The first level is reached when at least half of the sensors are surpassing these limits: 250 μg of sulphur monoxide/cm of air, an average of 200 μg of ozone/hr, 200 μg of nitrogen dioxide, and 10 μg of carbon monoxide. When these levels are reached, Milan's administration will ask the citizens to restrict the use of automobiles, limit domestic heating to only 12 hr/day, and keep old or ill people inside.

The second level of environmental alarm occurs when the 250 μg of sulphur monoxide/cm persists in the atmosphere for longer than 3 days. The alarm occurs immediately if the level reaches 500 μg , together with 400 μg of nitrogen dioxide, 300 μg of ozone, and 30 μg of carbon monoxide. In this case, the city administration will order a partial or total halt to private traffic, 20 percent decrease of powerplant activity, and 40 percent decrease of industrial activities, and will allow a maximum of 18° for home heating for only 12hr/day.

A Study for Better Agriculture With Less Pollution

The Ministry of Environment launched a project for a detailed study to obtain better agricultural crops with less environmental damage. The selected site is the island of Ariano Polesine which is 16,000 ha of land with varied and intensive agriculture. The project is expected to last 18 months and cost 2 billion Lire (about \$1.76 million). Snamprogetti Biotecnologie will study pollution reduction methods by recycling biomass and animal wastewater. The same company will also study recycling sludges obtained by purifying processes of urban and industrial waste. The other companies, Montedison Agriculture, CIR, and Deltaconsult, will experiment with types of agriculture more suitable to the zone and collect data from climate, hydrogeology, social conditions of the inhabitants, and marketing of the products. The project is part of the bigger project of relaunching the whole PO River delta and its clean up.

Conference on Research Management in Europe

A recent conference on research management drew representatives of the scientific, industrial, and government sectors to Florence from Europe, the U.S., and Japan. The topic became controversial and the participants did not reach a consensus. The traditional aversion of the scientist to being managed clashed with the desire of the European Commission and industry to be competitive. Proposals to establish a research managers association and training institution were not approved. The Japanese science council president will ask for U.S. scientists to join a new environmental institute doing global change research. The Bulgarian

Academy of Sciences President appealed for European Community funding for scientific equipment and noted a brain drain of young scientists.

Project to Map and Sequence *Bacillus Subtilis*

During a recent congress organized by Amity Amersham International in Cortona, Alessandro Galizzi, Professor of Micro-organism Genetics, University of Pavia, explained his studies on the mapping and sequencing of the Genome of the bacterium *Bacillus Subtilis*. European, Japanese, and North American research groups are participating in the project. The five European groups have received EC funding of 15 billion Lire (about \$13.3 million) for the first 18 months.

Bacillus Subtilis was selected because this bacterium produces spores. This renders it different than the normal bacterial cell in its structure, its components, and by the fact that it is metabolically inert. The spores survive at extreme temperatures (over 100° C) and resist the attack of chemical compounds so that the spores act as a shield to the bacterium which can resist for decades.

Galizzi's group seeks to individuate the mechanisms that regulate genetic expression. Some genes are activated only to produce the spores. Galizzi's group wants to know what are the ambient signals that determine the passage from bacteria to spore. During the process, the mutants are isolated and the group performs genetic analysis and direct molecular analysis of the DNA by cloning and sequencing it. The final objective is to determine the entire nucleotide sequence of the DNA of this bacterium (approximately five million base pairs). Because of the relative simplicity of the genetic analysis related to this bacterium, Professor Galizzi hopes that the project will be completed by 1997.

Italian Biotechnology Hampered by Lack of Regulation

Marco Nuti (Director of the Research Center for Innovative Biotechnology of the University of Padua and an EC expert on biotechnology) complained in the authoritative newspaper *Corriere Della Serra* that the lack of regulatory agency or guidelines for biotechnology in Italy hinders research. This "absurd" status of lack of authority and guidelines favors those who wish to genetically modify organisms without having to follow precise rules. On the other hand, universities, government research laboratories, and serious industrial laboratories are disadvantaged because they do not know to whom they should refer to carry on their research. Nuti contrasts this situation with countries that have appropriate rules for biotechnology and have therefore released up to 140 transgenic organisms under well-controlled experimental conditions.

The Universities of Catania and Padua, through genetic engineering, produced a mutant a few years ago for *pseudomonas syringae* which reduced the quantity of an ice-forming protein. The mutant could be used to

protect crops from frost. However, the attempt by the University of Catania to put this product into use to protect early crops of strawberries was prohibited by the Ministry of Agriculture for lack of precise guidelines. *Biotec Magazine* had already published results on this research but apparently the ministry did not find the results sufficient.

The bacterium *psuedomonas syringae* is a further example of the problems of biotechnology in Italy. The bacterium treated with x rays has been used in Italy under a U.S. (Kodak) patent to produce artificial snow in ski resorts. The bacterium is now under consideration for use in eliminating fog at airports, beginning with an experiment in Verona. Nuti says that it is possible that some small percentage of the many micro-organisms shot over mountain slopes remain unaffected by the x-ray treatment and therefore might cause secondary effects to their environment. He suggested that the Ministry of Agriculture and Forestry should supply figures on its evaluation of the probability that some of the micro-organisms are not biologically inert.

One issue that Nuti says must be tackled in the future is the evaluation of risk for environmental introductions. He advocates a risk assessment for any release of genetically altered organisms into the environment.

Italy Technology Roundup

Iron Metallurgy Innovation

The ENEA is directing development of a new iron metallurgy process. Cooperating in the venture are Arvedi (Italy) and Mannesmann Demag (Federal Republic of Germany). The process produces rolled steel sections in a unique cycle from liquid steel exploiting the energy contained in the steel poured at high temperature. The process is called inline strip production and will produce 500,000 tons of rolled steel sections annually. The advantage is a drastic reduction of the manufacturing line from 1,400 to 130 m. This is considerable saving of energy and drastic decrease of scraps.

New Telecommunications Satellite

The ASI has commissioned Selenia Spazio to construct ITALSAT 2 (the second telecommunication satellite) to be launched in 1992 costing 160 billion Lire (about \$139 million). ITALSAT 2, together with ITALSAT 1, will be capable of handling 12,000 telephone calls, plus FAX service, video conferences, and data and image transmission.

Tecnospazio Obtains Contract from ESA

The European Space Agency (ESA) assigned to Tecnospazio (a consortium between Comau and Fiat) the ground development of a manipulator of the offline programming system and of a simulator of the Columbus

control system. Tecnospazio is the prime contractor with Aeritalia, Dornier Matra, and MBB/ERNO.

Agency for European Research

Recently, the Agency for European Research was founded in Rome. The Italian Association of Industrialist (CONFINDUSTRIA), the Federation of Technical Association (FAST), and the Association of Chambers of Commerce jointly founded the Agency for European Research. The goal is to promote Italian participation in European research programs of development and innovation.

Whooping Cough Vaccine

The Italian research center of the Sclavo Institute in Siena has found a new vaccine with no side effects for whooping cough. Dr. Rino Rapuoli, who is responsible for manufacturing the new vaccine, said that it is a toxine produced by a bacterium from which those fragments responsible for toxic effects has been removed.

New Working Suit by ENEA

The ENEA has patented a new working suit that allows the worker to operate in an environment with temperatures varying from -20 to +50° C. The suit also filters polluting substances that might be present in the atmosphere (including toxic and nerve gases) and keeps constant the temperature in the interior of the suit.

Wind Energy Plant in Sardinia

The ENEL has tested for 800 hours a large wind powerplant called M30. The powerplant is formed by a rotor with a blade propeller measuring 33 m in diameter and can produce one million KW/H/year with winds as weak as 3.5 m. The ENEL has commissioned the company Riva Calzoni to produce 38 of these rotors for 700 million Lire each (about \$600,000) to make two wind powerplants in Sardinia and Central Italy. The Italian National Energy Plan requires that 3 percent of the national energy needs be supplied by wind by 2000.

Italian National Research Council Approves Targeted Research Project on Transportation

The CNR approved the financing of a second targeted research project on transportation with a total budget of 291 billion Lire (about \$257 million dollars) for 5 years. An estimated 162 billion Lire must be provided by participating industry. The project is divided into six subprojects: management of mobility, vehicles, technological systems of transportation support, urban and metropolitan transportation, freight transportation, and participation in international research programs.

Microgravity Agreement Between Italy and Japan

The Naples Microgravity Advanced Research and Support (MARS) center reached an agreement with the Japan Microgravity Center (JAMIC) for a joint research effort. The areas of cooperation are still to be identified. A JAMIC delegation visited the MARS center and saw

experiments of telescience through probe-rocket TEXUS and the Mars programs on artificial intelligence and expert systems. The MARS center was created by the cooperation between the Institute of Aerodynamics (University of Naples) and the Space System Group (Aeritalia).

Thin Films

The Casaccia Energy Research Center of ENEA is operating an advanced laboratory for the production of thin films to be employed in many scientific areas, especially for laser mirrors. The production will not be marketed, but the technology will be immediately released to industry. The laboratory cost about 10 billion Lire (about \$9 million) and will operate in close cooperation with industries like Pirelli, Contek, Galileo, and Selenia. The laboratory has a section for technology development through traditional facilities; e.g., sputtering, and more advanced ones; e.g., dual ion beam sputtering, and a section for measuring and characterizing optical and mechanical properties of films and substrata.

Ansaldo is Reorganizing its Research

Ansaldo has reorganized its new technology division in five areas:

1. Energy systems - nuclear fusion, fuel cells with acid phosphoric experimental plants from 1 to 10 MW, magnetohydrodynamics (MHD) to test components for superconductivity in MHD, transmission and storage of electricity with semiconductors or with superconducting magnets
2. Electronics - power conversion, process control, expert systems, data processing
3. Components qualifications - energy products, railway, naval industry, construction
4. Structural analysis - stress analysis, modal and seismic nonlinear dynamics
5. New products - devices for particles accelerators, components for space applications, robotics, advanced combustion.

CNR Pyramid on Mount Everest

The CNR is operating the aluminum/glass structure shaped as a pyramid to house researchers and scientific equipment on Mount Everest at 5,050 m of altitude. The project was first intended for the Tibetan side of the mountain with the support of the Chinese Academy of Science. After the Tienamin Square events, it had to be moved on the Nepalese side and started again. The pyramid structure (8 m high with a base of 187 sq.m) has been in place since September 1990. The structure may resist winds of 150 km/hr and temperature changes of 70° and resist snow and ice weighing up to 100 km/sq.m. A 3-KW photovoltaic plant and a 6-KW hydraulic plant are supplying energy while the waste is disposed of with a

small incinerator. The pyramid houses about 60 persons--36 Italian researchers; 12 Nepalese scientists, mountain guides, and other personnel; plus 3,000 k of scientific equipment. The research focuses on high-altitude research on medicine, biology, physiology, meteorology, and hydrology. The research program is divided into four principal areas:

1. Earth sciences - 15 researchers on geodesy, geology, geomorphology
2. Environmental sciences - 4 researchers on applied hydrobiology and atmospheric pollution
3. Biological science - 14 researchers on physiology, nutritional sciences, cardiology, zoology, and botanics
4. Human sciences - 2 researchers on cultural aspects of the northern Nepal populations.

Human Genome

Prof. Renato Dulbecco said that he completed the strategic project on Human Genoma sponsored by CNR with 6 billion Lire (about \$5.2 million) for 3 years. He will now direct the subproject Genoma of the CNR Genetic Engineering targeted research project. The Genoma subproject will benefit from 12.5 billion Lire (about \$10.8 million) financing for 5 years. Although the CNR funds destined for the Genoma research are only 1 percent of the CNR funds for biological research, the sum does not include salaries or expenditures for the functioning of the structures. The Italian Genoma project is limited to the chromosome X. During the last 3 years, numerous data were collected and made available to the scientific community. Many specific points of the chromosome were identified and fragments were cloned.

Technology Deficit of Italian Industry

The Ministry of University and Scientific Research (MURST) has conducted a study on Italian industrial research revealing a substantial deficit in the import/export of technology. However, as with small and medium Japanese industry, Italian industry was able to import technology, spending less money than in establishing its own research. Italy is also profiting very little from the possibility of research financing offered by the EC. In a study conducted during the semester of the Italian EC Presidency, it was found that only 14 percent of industries created a research department through EC funding, and 37 percent of these industries say that their research department was a very recent acquisition. The EC programs most responsible for encouraging in Italian industrial management the concept of research were (in order): ESPRIT, BRITE, RACE, energy programs, management of radioactive waste, and new materials.

New Asphalt Against Traffic Noise

The Italian company FIMIT/IPSE has devised a new type of asphalt that reduces the traffic noise from 3.4 to

5.2 dB in automobiles driving at 120 km/hour. The company was originally asked by the Italian Society of Highways (Society) to find a type of porous asphalt that would facilitate the absorption of rainwater from the road surface. This type of asphalt, in addition to its water draining feature, unexpectedly revealed its ability to decrease road traffic noise caused not only by tires on the road surface, but also absorbing the noise coming from the automobile engine. The Society is testing the new asphalt on three national highways, and FIMIT/IPSE is studying the possibility of using it on city streets to decrease urban traffic noise.

Frascati INFN Equipped With Gravitational Antennas

The Rome University gravitational waves group has completed at the CERN the construction of a gravitational antenna called Explorer to measure the effects of relativity. Explorer is formed by an aluminum cylinder 3 m long, weighing 2.3 tons and is suspended by titanium cables in a vacuum room cooled to the 1.8K (about -271). The low temperature is necessary to cancel the natural thermic vibration of the molecules and atoms of the metal, thus making the antenna extremely sensitive only to the vibration induced by gravitational waves. The same type of antenna called ALTAIR (weighing only 390 kg) is being completed at the laboratory of the National Institute of Nuclear Physics (INFN) of Frascati. The INFN Frascati laboratory is also building an antenna twin of the explorer called NAUTILUS cooled at 50 mK to be transferred from CERN to Frascati in a year. With this equipment, the INFN Frascati laboratory will be able to detect gravitational phenomena occurring at great distances in space.

In Milan Methane Burns Without Producing Carbon Dioxide

In an effort to minimize the production of carbon dioxide, the Polytechnic of Milan has devised and patented a new method for burning methane. Normally, methane burns by reacting with two molecules of oxygen and forming one molecule of carbon dioxide and two molecules of water. With the special chemical reactor devised by the Milan Polytechnic, methane burns by reacting with only one molecule of oxygen and forming carbonium and two molecules of water. The new method, however, is estimated to double the cost of a KW/H because of the higher consumption of methane to produce the same quantity of heat obtained in traditional burning. In addition, the tons of carbon formed in a 1,000-MW powerplant functioning with this system would create a problem of disposal or reuse, increasing the overall cost of the operation.

Italy Will Participate in SANGER

Italy plans to join through its company Alenia (Selenia Spazio/Aeritalia), with the German Deutsche Aerospace, to study SANGER, an earth to orbit plane for the

generation following the shuttle, and the HERMES. Sweden is already participating and Italy will participate with 15 percent of the joint project. SANGER will launch a space vehicle anchored on its deck, after reaching 30 KM of altitude. SANGER will be able to leave and land from any airport runway. The prototype should be completed by 1996, while the first flight should be in 2006. The technology developed by SANGER should lead to the construction of a passenger airplane traveling at the supersonic speed of 5,000 KM/hr. The cost of the operation is not yet known, but is expected to be very high. Italian Undersecretary for Scientific Research, Sen. Learco Saporito, said that to prepare for this project, he will present to the Italian Parliament a proposal for the establishment of a fund for aeronautical industry use that will be independent from the 4-year finance plan approved for ASI.

The Mario Negri Institute of Pharmacological Research

The Mario Negri Institute of Pharmacological Research is a private organization founded in 1961 that quickly reached an advanced level of biomedical research under Professor Silvio Garattini. The research areas are:

- Cancer - one third of the research effort dealing especially with chemotherapy and immunology of tumors
- Mental and nervous diseases - special emphasis on understanding how the brain and the nervous systems work and how drugs act on them
- Heart diseases - concentrating on Arteriosclerosis, blood clotting, heart attacks, strokes, and aging process
- Kidney diseases.

The institute is cooperating with and making available its research to more than 500 hospitals throughout Italy. The functioning of the institute costs about 20 billion Lire per year (about \$17 million dollars) provided by donations, subsidies, grants, and research contracts.

Spain

For further information on Spain items, contact Leroy C. Simpkins, Office of Science Attache, American Embassy, Madrid, APO New York 09285.

Vandellos Nuclear Plant to be Dismantled

The 500-MW nuclear plant Vandellos I, near Barcelona, will be dismantled at a cost of approximately \$800 million. The French-designed, gas-cooled reactor plant, built in 1972, stopped operation in October 1989 after fire and water damage resulted from a turbine failure. There was no radioactive release. Since Spain has no reprocessing facility, the cost estimate is \$300 million for removal of 400 tons of fuel to France over

5 years. Spain now has nine nuclear plants producing 7,300 MW of electrical power (38 percent of the total).

Waste Disposal Without Reprocessing

The National Nuclear Waste Enterprise (ENRESA) announced wastes from Spain's nine operating nuclear plants would be buried rather than reprocessed. A disposal system is being tested. In this system, high-level waste is packed in steel drums and topped off with clay. Then the waste is placed in underground salt or granite deposits. Final site selection and emplacement are at least 5 years off. Since 1986, Spain has participated in an EC research project on waste disposal that uses the Fanay Center near Limoges, France. The ENRESA says the disposal plan is cheaper than reprocessing. Spain's low-level waste plant is at El Cabril in Cordoba Province. In 1987, ecological groups forced abandonment of an underground high-level waste pilot plant in Salamanca Province.

Spain's Lack of Environmental Policy Could Boomerang

The EC is looking for a location for its new European Environmental Agency, and Spain is one of the bidders. However, Spain is the only EC country without an independent environmental authority. A European Parliamentarian charged that Spain has chosen development over ecology. A recent poll revealed that public characterization of pollution as serious or very serious has increased to 86 percent. In addition, 69 percent of those polled believe that the government is doing too little to fight pollution.

Spain Proposes Latin American EUREKA Program

In the framework of its multilateral technology cooperation program with Portugal and 19 Latin American countries, Spain has designed a Latin American EUREKA subprogram to extend the activity to industrial as well as government laboratories. Started in 1984, the program is modeled on the EC's European Research Cooperation Agency (EUREKA) Program. Spain's Center for Industrial Technological Development (CDTI) and the Ministry of Industry plan to finance up to 70 percent of Spanish firms' participation in the new subprogram. Spanish officials point to successfully completed projects with government laboratories such as one with Mexico, Brazil, Venezuela, and Argentina, on catalytic oil refining (\$2 million) and another with the same countries (plus Chile) in computer sciences.

Boom Industry Needs University Graduates

There were 160,000 new university students this fall in Spain; the total enrollment at the 35 public and 4 private universities will probably be over 1 million. Yet if past experience holds, some 55 percent will never graduate. For those who enter, limited staff and facilities in some

specialties will bar one student out of five from following his first choice of major study.

Employment prospects in economically booming Spain are high in fields of management and technology. In the latter area, telecommunications, computer sciences, industrial engineering, civil engineering, and agronomy are areas awaiting graduates whose university careers will span 4 to 7 years. This educational system is the source of Spain's S&T manpower pool, which currently amounts to 25,000 (full-time equivalent) researchers. Of these, 30 percent are employed by private industry. This is about 4 percent of the total researchers in the EC.

As Spain moves toward closer European integration and competition, its educational system, as a source of ideas, managers, and engineers, will remain a focus of attention. In 1992, possibilities for students from any EC country to study at any member country's universities will also be greatly increased.

Research Spotlight

The National Center for Metallurgical Research (CENIM) at the University of Madrid is the largest of the 90 national research centers operated by the Council for Scientific Research (CSIC) (a sort of Spanish NSF). Two hundred and fifty researchers and support personnel work in iron and steel, nonferrous metals, bonding or joining, transformations, corrosion, physical metallurgy, and metallurgical chemistry. Some of the researchers also teach at the university, and students work with them on thesis projects. Special attention to work on physical metallurgy shows recent and current projects on superalloys, glassy metals, powder metallurgy, superplasticity, heat treatment (annealing, tempering). In collaboration with Stanford University, one project deals with fabrication of ultra high-strength steels, a possible rediscovery of Damascus steel.

A tour of CENIM reveals modern spaces, plentiful equipment, and intense activity in its large main building and five smaller ones. The library has over 10,000 volumes and subscribes to some 500 journals. CENIM publishes two journals--*Revista de Soldadura* (Bonding Review) and *Revista de Metalurgia* (Metallurgy Review). Both are international with international editorial boards. Papers are generally in Spanish with English abstracts.

Human Genome Conference in Valencia

Valencia hosted a conference on the human genome. The human genome is the set of 24 chromosomes, their 100,000 genes, and their billions of bits of DNA that completely characterize humans and their propagation. A focus of the meeting was ethical problems of the international human genome project that is designed to identify every part of the genome. This conference was one of the first international conferences on ethics in molecular biology since the Asilomar meeting in 1975. Invitees included nobelists James Watson from the U.S. and Severo Ochoa from Spain.

World Climate Conference

The World Climate Conference received considerable press coverage in Spain. Papers reviewed the scientific arguments, including those for cutting CO² emissions 20 percent by 2005 along with the economic consequences of such a reduction. One report reminded readers that alternative power sources are not appropriate for every country. The financial daily *Cinco Dias* termed the climate conference a failure.

Hazardous Waste Dump Problems

Government specialists admit that the problems in Spain presented by up to 100,000 unmonitored waste dumps are urgent, based on preview of a government study done for completion in 1991. Industrial waste production is estimated at 1.7 to 1.8 million metric tons/yr, with nearly half produced in Catalonia and the Basque country. Spain even imports waste, notably that containing mercury. One official commented that there is not more environmental administration because the people don't demand it.

Antarctic Summer Cruise Begins Conservation

At the end of November 1990, the research ship *Las Palmas* on the fourth Spanish Antarctic cruise, arrived at Juan Carlos I base on Livingston Island off the east coast of the Antarctic peninsula. Two groups of scientists joined the ship by plane. The scientists will make hydrographic measurements between Livingston and Deception Islands. Land-based research will focus on biology, medical science, and geophysics project (some in cooperation with Argentina and Chile). The Spanish government announced that Spain would not adhere to the Antarctic minerals regime (the Wellington Treaty).

Spain is Likely Spot for HERMES Landing Site

According to Spanish officials, the ESA has all but finally selected Almeria, in Southern Spain, as the landing base for the HERMES. First launch of HERMES from Kourou, French Guiana, is scheduled for 1998. This will be unmanned, followed by a manned launch in 1999. Spain's participation in ESA projects for 1991 is reckoned at \$130 million (up 20 percent over 1990). The Spanish firm Cecelsa has offered to prepare the Almeria airport for about \$40 million. Other HERMES support projects: an astronaut training center and flight control center in Toulouse, a flight simulator, a flight model, and development of flight software. Over time, these projects would bring Cecelsa a significant share of their \$500-million cost. Total cost estimate for HERMES is \$5 billion.

Canary Islands Sky Will Become Astronomical Preserve

Beginning in 1991, a "Law of the Sky" will reduce light pollution and preserve atmospheric quality in the Canary Islands to facilitate astronomical observations. Termed unprecedented, the law provides for limiting or deflecting downward-most lighting on the islands of La Palma and Tenerife, sites of international observatories of the Astrophysics Institute of the Canary Islands. Locations of industry, airline flight routes, and radio emissions will

also be controlled. Although the 20-some telescopes and other observing devices are located 2,000 m or more above sea level, light pollution from towns on the coast diminishes their efficiency. Controls will be strictest on La Palma where the government will spend more than \$3 million over 3 years to help modify outdoor lighting. In 1986, residents of La Palma voluntarily turned out all their lights to ease the observations of Halley's comet from the observatory there. Spain hopes that the new law will help attract the new 8-m, optical-infrared reflecting telescope to the Canaries. The U.K. would finance half of the \$60-million project. The U.K. and Canada are believed to prefer to locate the new telescope in Hawaii. The large earth-based solar telescope is definitely slated for the Canaries and due to begin operation in 1996.

Nuclear energy expansion prospects remain dim and political opposition still block expansion of Spanish nuclear power. Unfinished plants are being stripped of components for use as replacement parts in operating plants. A construction moratorium in 1984 left five plants unfinished. Four of the plants were over half completed when stopped, and had cost \$1 to 2 billion each. Spain will probably meet incremental electricity needs by buying electricity from France. Since some unfinished plants were similar to those in operation, some cannibalizing has taken place.